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Teacher's Leaflets on Nature Study

Cornell University College of Agriculture, New York State College of Agriculture, Cornell university, ...

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MISCELLANEOUS NOTES.

Home Nature-Study Course.

A Home Nature-Study Course for teachers has been established for the benefit of those who wish to carry on a line of study in connection with their teaching, and through vacation, but who cannot undertake the work of a summer school.

The course consists of printed matter selected for the purpose from the publications of the Bureau of Nature-Study, together with a quiz. This quiz is a series of questions, but should be regarded as a report of progress and not as an examination.

Lesson 1 on the germination of seeds is already in the hands of some five hundred teachers. Lesson 2 is on the subject of life in an aquarium with special reference to the study of the development of the toad and the frog. Both lessons will be sent on application, and others will follow as issued.

It is hoped that groups of teachers in one school or locality, training classes, and others preparing to teach, will take up this Home Nature-Study Course.

Synopsis of the Extension Work.

The State Extension Work in Agriculture prosecuted by the College of Agriculture of Cornell University, proceeds along the following lines:

I. *Coöperative experimentation*, the results of which are reported in the regular bulletins of the Station.

II. *Nature-Study and Farmer's Reading Course.*—The Nature-study movement proceeds along several lines, of which the following are chief:

(1.) Efforts to reach the children through the teacher, by means of:
- Teacher's leaflets.
- Instruction at teachers' institutes.
- Instruction at State summer schools.
- Instruction in a school of nature-study at Cornell University.
- Home nature-study course.
- Personal correspondence.

(2.) Efforts to reach the children directly, by means of:
- Naturalist clubs.
- Children's leaflets.
- Making of gardens.
- Collecting of insects.
- Holding of flower-shows.
- Personal correspondence.

Correspondence may be addressed to *Bureau of Nature-Study*, Ithaca, N.Y.

L. H. Bailey, Chief.

John W. Spencer, Deputy Chief.

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D. L. Bunnell

TC DEC 9 GIFT

UNIV. OF CALIFORNIA

June, 1899.

CORNELL NATURE-STUDY ~~BULLETIN~~ Quarterly

No. 1.

Teacher's leaflet no. 1

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Cornell University

Issued by the College of Agriculture and Experiment Station of Cornell University, under Chapter 430 of the Laws of 1899, of the State of New York. I. P. Roberts, Director.

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A HANDFUL OF SOIL.

PART I: WHAT IT IS.

BY R. S. TARR.

WIND drifts a seed from the parent plant until it settles to the ground, perhaps in a field or by the roadside, or even in the school-yard. There it remains through the long winter; but with the return of spring, encouraged by the warm sunlight, the seed awakens from its dormant condition, breaks open the seed-cover and sends leaves into the air and roots into the ground. No one planted the weed; but it has made its way in the world and it thrives until it has given to other seeds the same opportunity to start in life.

Had the seed fallen upon a board or a stone, it might have sent out leaves and roots; but all in vain, for something was lacking and that seed was a failure in life. What is there in the soil that is so necessary to the success of plant life? And how has it come to be there? Indeed, what is this soil that plants need so much? These are some of the questions which we will try to answer.

One readily sees that the soil furnishes a place for the plants to fix themselves; an anchorage, as it were. It is also easy to see that from the soil the plants obtain a supply of water; and, moreover, that this water is very necessary, for the vegetation in a moist country suffers greatly in time of drought, and few plants are able to grow in a desert region because there is so little water. You can make a desert in the school room and contrast it with moist soil by planting seeds in two dishes of soil, watering one dish, but furnishing none to the other.

That water is necessary to plants is also proved by the plant itself. The sap and the moisture which may be pressed out of

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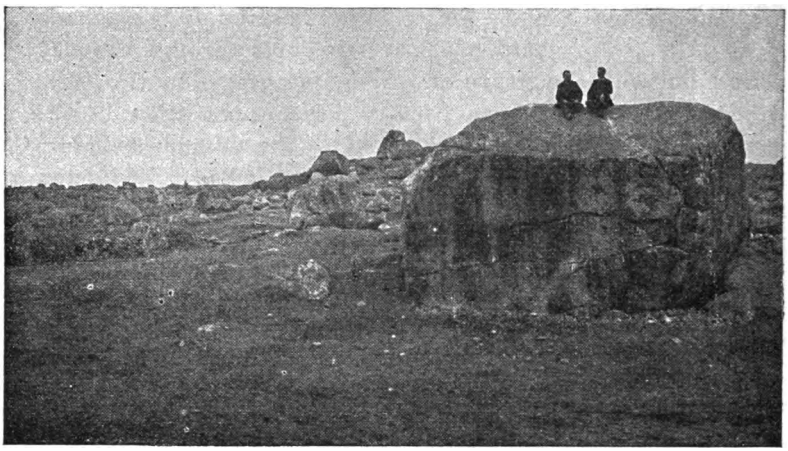
a grass stem or an apple are principally water taken from the soil by the roots. But there is more than water, for the juice of an apple is sweet or sour, while the sap and juice of other plants may be sweet or bitter. There are some substances dissolved in the water.

It is these dissolved substances that the plants need for their growth, and they find them ready for use in the soil. There is a plant-food which the roots seek and find, so that every plant which sends roots into the soil takes something from it to build in the plant tissue. The sharp edges of some sedges, which will cut the hand like a dull knife, and the wood ashes left when a wood



14.—*A boulder-strewn soil of glacial origin with one of the large erratics on the right similar to those which early attracted attention to the drift.* *See page 42.*

fire is burned, represent in part this plant-food obtained from the soil.

Let us take a handful of soil from the field, the school yard, or the street and examine it. We find it to be dirt that "soils" the hands; and when we try to brush off the dirt we notice a gritty feeling that is quite disagreeable. This is due to the bits of mineral in the soil; and that these are hard, even harder than a pin, may often be proved by rubbing soil against a piece of glass, which the hard bits will scratch, while a pin will not.

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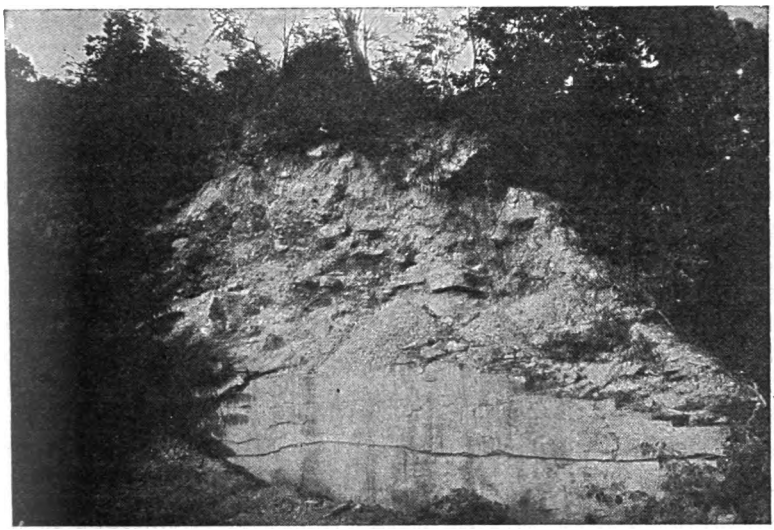
Study this soil with the eye and you may not see the tiny bits, though in sandy soils one may easily notice that they are bits of mineral. Even fine, loamy and clay soils when examined with a pocket lens or a microscope will be found to be composed of tiny fragments of mineral. It is evident that in some way mineral has been powdered up to form the soil; and since the minerals come from rocks, it is the rocks that have been ground up. That powdered rock will make just such a substance as soil may be proved by pounding a pebble to bits, or by collecting



15.—*A glacial soil, containing numerous transported pebbles and boulders, resting on the bed rock.*

some of the rock dust that is made when a hole is drilled in a rock. Much the same substance is ground from a grindstone when a knife is sharpened on it, making the water muddy like that in a mud hole.

It will be an interesting experiment to reduce a pebble to powder and plant seeds in it to see if they will grow as well as in soil; but in preparing it try to avoid using a sandstone pebble, because sandy soils are never very fertile.

Not only is soil made up of bits of powdered rock, but it

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everywhere rests upon rock (Fig. 15). Some consider soil to be only the surface layers in which plants grow; but really this is, in most places, essentially the same as the layers below, down even to the very rock, so that we might call it all soil, though, since a special name, *regolith* (meaning stone blanket), has been proposed for all the soft, soil-like rock-cover, we may speak of it as regolith and reserve the word soil for the surface layers only.

In some places there is no soil on the bare rocks; elsewhere the soil-cover is a foot or two in depth; but there are places where the regolith is several hundred feet deep. In such places, even the wells do not reach the rocks; nor do the streams cut down to it; but even there, if one should dig deep enough, he would reach the solid rock beneath.

How has this hard rock been changed to loose soil? One of the ways, of which there are several, may be easily studied whenever a rock has been exposed to the air. Let us go to a stone wall or among the pebbles in a field, for instance, and, chipping off the surface, notice how different the inside is from the outside. The outer crust is rusted and possibly quite soft, while the interior is hard and fresher. Many excellent examples of this may be seen in any stony field or stone wall.

As hard iron rusts and crumbles to powder when exposed to the weather, so will the minerals and the rocks decay and fall to bits; but rocks require a very much greater time for this than does iron. It happens that the soil of New York has not been produced by the decay of rock; and, therefore, although most soils of the world have been formed in this way, we will not delay longer in studying it now, nor in considering the exact way in which rocks are enabled to crumble.

Another way in which rocks may be powdered may also be seen in most parts of New York. The rains wash soil from the hillsides and the streams become muddy. In them there are also many pebbles, representing the larger fragments that have fallen into the stream after having been broken from the ledges. The current carries these all along down the stream, and, as they go, one piece striking against another, or being dragged over the rocks in the stream bed, the pebbles are ground down and smoothed (Fig. 16), which means, of course, that more mud

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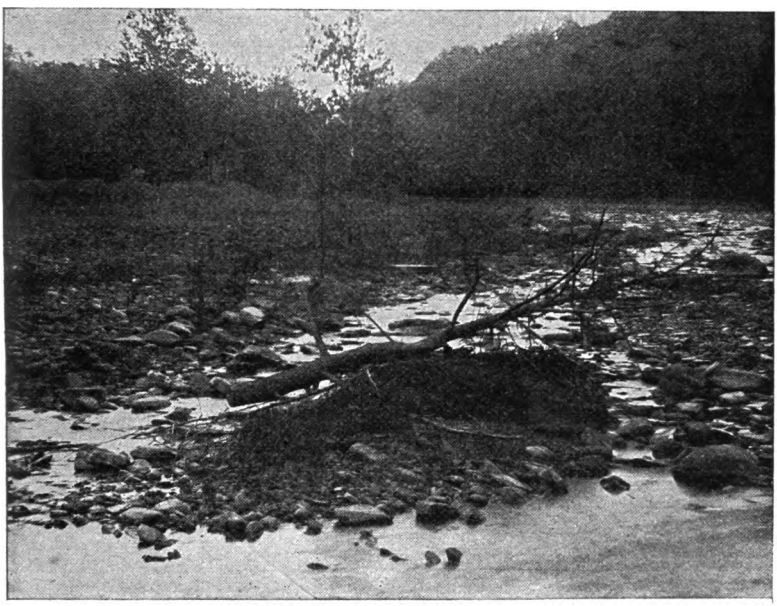
is supplied to the stream, as mud is furnished from a grindstone when a knife or scythe is being sharpened on it. On the pebbly beaches of the sea or lakeshore much the same thing may be seen; and here also the constant grinding of the rocks together, wears off the edges until the pebbles become smooth and round.

Supplied with bits of rock from the soil, or ground from the pebbles and rocks along its course, the stream carries its load



16.—*The bed of a stream at low water, revealing the rounded pebbles that have been worn and smoothed by being rolled about, thus grinding off tiny bits which later are built into the flood-plains.*

onward perhaps to a lake, which it commences to fill, forming a broad delta of level and fertile land, near where the stream enters the lake. Or, possibly, the stream enters the sea and builds a delta there, as the Mississippi river has done.

But much of the mud does not reach the sea. The greatest supply comes when the streams are so flooded by heavy rains or melting snows, that the river channel is no longer able to hold

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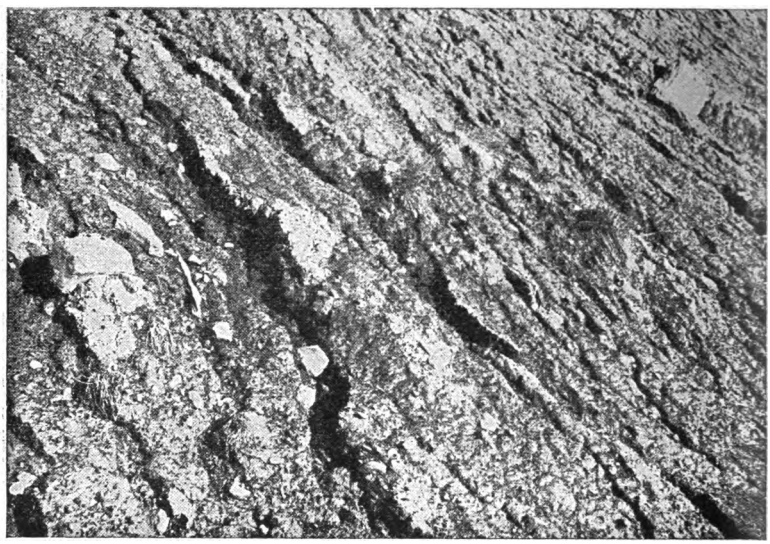
the water, which then rises above the banks overflowing the surrounding country. Then, since its current is checked where it is so shallow, the water drops some of its load of rock bits on the flood-plain, much as the muddy water in a gutter drops sand or mud on the sidewalk when, in time of heavy rains, it overflows the sidewalk.

Many of the most fertile lands of the world are flood-plains of this kind, where sediment, gathered by the streams farther up their courses, is dropped upon the flood-plains, enriching them by



17.—*Near view of a cut in glacial soil, gullied by the rains, and with numerous transported pebbles embedded in the rock flour.*

new layers of fertile soil. One does not need to go to the Nile, the Yellow or the Mississippi for illustrations of this; they abound on every hand and many thousands of illustrations, great and small, may be found in the State of New York. Doubtless you can find one.

There are other ways in which soils may be formed (Fig. 17); but only one more will be considered, and that is the way in which most of the soils of New York have been made. To study this

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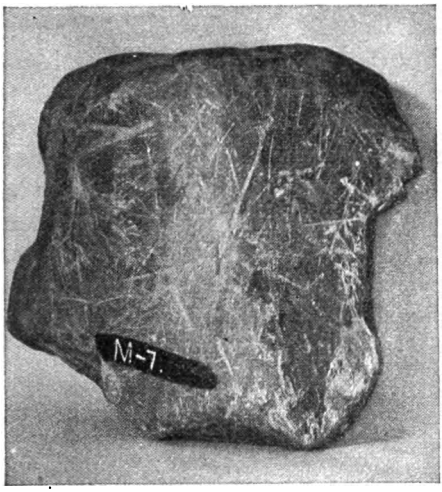
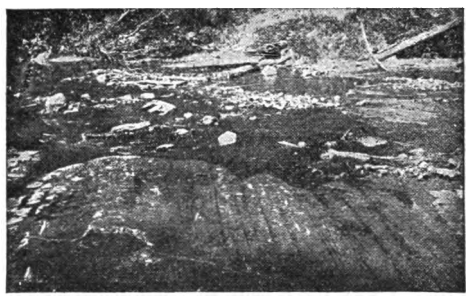
let us go to a cut in the earth, such as a well or a stream bank (Figs. 15 and 17). Scattered through the soil numerous pebbles and boulders will doubtless be found; and if they are compared with the solid or bed rock of the country, which underlies the soil (Fig. 15), some of them will be found to be quite different from it. For instance, where the bed rock is shale or limestone, some of the pebbles will no doubt be granite, sandstone, etc. If you could explore, you would find just such rocks to the north of you, perhaps one or two hundred miles away in Canada; or, if your home is south of the Adirondacks, you might trace them in those mountains.



18.—*A scratched limestone pebble taken from a glacial soil.*

On some of these pebbles, especially the softer ones, such as limestone, you will find scratches, as if they had been ground forcibly together (Fig. 18). Looking now at the bed rock in some place from which the soil has been recently removed, you will find it also scratched and grooved (Fig. 19); and if you take the direction of these scratches with the compass, you will find that they extend in a general north and south direction, pointing in fact in the same direction from which the pebbles have come.



19.—*The grooved bed rock scratched by the movement of the ice sheet over it.*

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All over northeastern North America and northwestern Europe the soil is of the same nature as that just described. In our own country this kind of soil reaches down as far as the edge of the shaded area in the Map (Fig. 20) and it will be noticed that all of New York is within that area excepting the extreme southwestern part near the southern end of Chautauqua lake.

Not only is the soil peculiar within this district but there are many small hills of clay or sand, or sometimes of both together (Figs. 26 and 27). They rise in hummocky form and often have deep pits or kettle-shaped basins between, sometimes, when the soil is clayey enough to hold water, containing tiny pools. These hills extend in somewhat irregular ranges stretching across country from the east toward the west. The position of some of these ranges is indicated on the map (Fig. 20).

For a long time people wondered how this soil with its foreign pebbles and boulders, altogether called "drift," came to be placed where they are; they were especially puzzled to tell how the large boulders, called erratics (Fig. 14), should have been carried from one place to another. It was suggested that they came from the bursting of planets, from comets, from the explosion of mountains, from floods, and in other ways equally unlikely; but Louis Agassiz, studying the glaciers of the Alps and the country round about, was impressed by the resemblance between the "drift" and the materials carried by living glaciers.

Agassiz, therefore, proposed the hypothesis that glaciers had carried the drift and left it where we now find it; but for many years his glacial hypothesis met with a great deal of opposition because it seemed impossible that the climate could have changed so greatly as to cover what is now a temperate land with a great sheet of ice. Indeed, even now, although all who have especially studied the subject are convinced, many people, even those who are educated in some directions, have not accepted Agassiz's explanation, just as years ago, long after it was proved that the earth rotated each day, many people still believed that it was the sun, not the earth, that was moving.

The glacial explanation is as certain as that the earth rotates. For some reason, which we do not know, the climate changed and allowed ice to cover temperate lands, as before that, the

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20.—*Map showing the extent of the ice sheet in the United States. Position of some of the moraines indicated by heavily shaded lines.* (*After Chamberlain.*)

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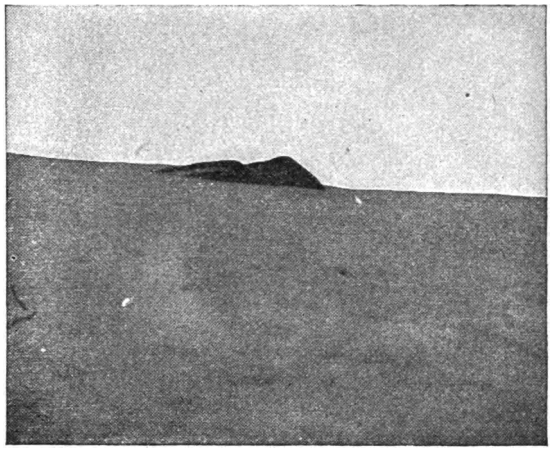
climate had changed so as to allow plants like those now growing as far south as Virginia, to live in Greenland, now ice covered. When the ice of the glacier melted away it left only signs of its presence; but when the temperate latitude plants grew in Greenland they left seeds, leaves and tree trunks which have been imbedded in the rocks as fossils. One may now pick the leaves of temperate climate trees from the rocks beneath a great icecap.



21.—*A view over the great ice plateau of Greenland with a mountain peak projecting above it.*

Nevertheless, to one who studies them, the signs left by the glacier are as clear proof as the leaves and seeds. From these signs we know that the climate has changed slowly, but we have not yet learned why it changed.

There are now two places on the earth where vast glaciers, or ice sheets, cover immense areas of land, one in the Antarctic, a region very little known, the other in Greenland, where there is an ice sheet covering land having an area more than ten times that of the State of New York. Let us go to this region to see what is being done there, in order to compare it with what has been done in New York.

In the interior is a vast plateau of ice, in places over 10,000 feet high, a great icy desert (Fig. 21), where absolutely no life of any kind, either animal or plant, can exist and where it never rains, but where even in the middle of summer the storms bring snow. Such must have been the condition in northeastern America during the glacial period.

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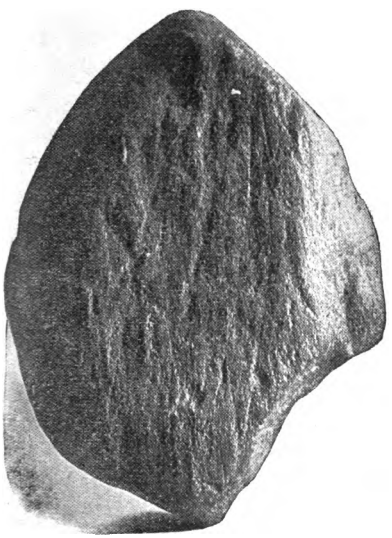
This vast ice sheet is slowly moving outward in all directions from the elevated center, much as a pile of wax may be made to flow outward by placing a heavy weight upon the middle. Moving toward the north, east, south and west this glacier must of course come to an end somewhere. In places, usually at the heads of bays, the end is in the sea, as the end of our glacier must have been off the shores of New England. From these sea-ends, icebergs constantly break off; and, floating away toward the south, often reach, before they melt, as far as the path followed by the steamers from the United States to Europe. Between the bays, where the glacier ends in the sea, the ice front rests on the land (Fig. 22), as it did over the greater part of New York and the states further west. There it melts in the summer, supplying streams with water and filling many small ponds and lakes. The front stands there year after year, sometimes moving a little ahead, again melting further back so as to reveal the rocks on which it formerly rested.

22.—*The edge of a part of the great Greenland ice sheet (on the left) resting on the land, over which are strewn many boulders brought by the ice and left there when it melted.*



23.—*A scratched pebble taken from the ice of the Greenland glacier.*

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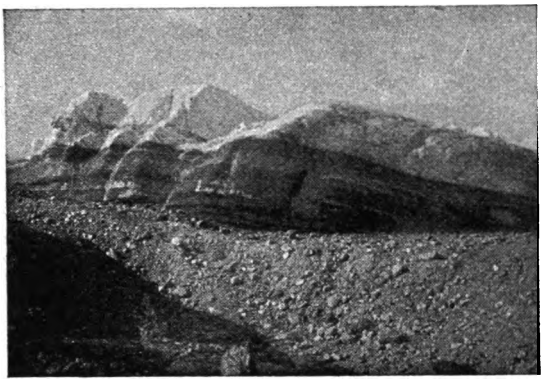
Examining this rock it is found to be polished, scratched and grooved just like the bed-rock in New York; and the scratches extend in the direction from which the ice moves. Resting on the rock are boulders and pebbles (Fig. 22), sometimes on the bare rock, sometimes imbedded in a clay as they are with us. As we found when studying the soil in our own region, so here the pebbles are often scratched, and many of them are quite different from the rock on which they rest.



24.—*A part of the edge of the Greenland glacier, clean white ice above, and dark discolored bands below where laden with rock fragments. In the foreground is a boulder-strewn moraine.*

Going nearer to the ice we find the lower part loaded with pebbles, boulders and bits of clay quite like those on the rocks near by. Fig. 23 shows one of these, scratched and grooved, which I once dug from the ice of this very glacier. The bottom of the ice is like a huge sandpaper, being dragged over the bed rock with tremendous force. It carries a load of rock fragments, and as it moves obtains more by grinding or prying them from the rocks beneath. These all travel on toward the edge of the ice,

25.—*Hummocky surface of the boulder-strewn moraine of Greenland.*

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being constantly ground finer and finer as wheat is ground when it goes through the mill. Indeed the resemblance is so close that the clay coming from this grinding action is often called *rock flour*.

Dragged to the front of the ice, the rock bits, great and small, roll out as the ice melts, some, especially the finest, being carried away in the water, which is always muddy with the rock flour it carries; but much remains near the edge of the ice forming a *moraine* (Figs. 24 and 25). This moraine, dumped at the

26.—*A view over the hummocky surface of a part of the moraine of the great American ice sheet in Central New York.*

edge of the glacier, very closely resembles the hummocky hills of New York (Figs. 26 and 27), mentioned above, which are really moraines formed at the ice edge during the glacial period. While their form is quite alike, the New York moraines are generally less pebbly than the Greenland moraines, because the Greenland glacier carries less rock flour than did the glacier which covered New York.

In the Greenland glacier, as you can see in Fig. 24 there is much dirt and rock; in the glacier of the glacial period

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there was even more. When it melted away the ice disappeared as water, but the rock fragments of course fell down upon the rock beneath and formed soil. If over a certain region, as for instance over your home, the ice carried a great load of drift, when this gradually settled down, as the ice melted, it formed a deep layer of soil; but if the glacier had only a small load a shallow soil was left. Again, if the ice front remained for a long time near a certain place, as near your home, it kept bringing and dumping rock fragments to form moraines, which, of course, would continue to grow higher so long as the ice dumped it, much as a sand pile will continue to grow higher so long as fresh loads are brought and dumped.

There are other causes for differences in the glacial soils, but most of them cannot be considered here. One of them is so important, however, that it must be mentioned. With the melting of so much ice, vast floods of water were caused, and these came from the ice, perhaps in places where there are now no streams, or at best small ones. These rapid currents carried off much of the rock flour and left the coarser and heavier sand, gravel, or pebbles, the latter often well rounded, with the scratches removed by the long continued rolling about in the glacial stream bed.

One often finds such beds of sand or gravel in different parts of the state, telling not only of ice where it is now absent, but of water currents where is now dry land. The rock flour was in some cases carried to the sea, elsewhere to lakes, or in still other places deposited in the flood-plains of the glacier-fed rivers. Now some of this rock flour is dug out to make into bricks.

Enough has been said to show that the soils of New York were brought by a glacier and to point out that there are many differences in the thickness of the soil as well as in kind and condition. The agriculture of the State is greatly influenced by these differences. In some cases one part of a farm has a deep, rich soil, another part a barren, sandy, pebbly or boulder covered soil (Fig. 14), while in still another part the bed rock may be so near the surface that it does not pay to clear it. Moreover, some farms are in hummocky moraines, while others, near by are on level plains (Fig. 27), where a broad glacial stream built up a

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flood-plain in a place where now the stream is so small that it never rises high enough to overflow the plain.

There are even other differences than these and one who is familiar with a region is often puzzled to explain them; but they are all due to the glacier or to the water furnished by its melting, and a careful study by a student of the subject of Glacial Geology will serve to explain them. Each place has had peculiar conditions and it would be necessary to study each place carefully in order to explain all the differences much further than has been done here.

27.—*Hummocky moraine hills in the background and a level gravel plain, —an ancient glacial-stream flood-plain—in foreground.*

Not only is agriculture influenced greatly by the differences in the soil from place to place, but also by the very fact that they are glacial soils. In a soil that has been formed by the decay of rock some of the materials needed by plants, the plant foods, have been leached out and carried off by the water while the rock was decaying; but the glacial soils have most of these foods still stored up for use. Here the minerals are simply ground up and not much decayed, while in the other case they are badly decayed, the difference being something like that between iron filings which are able to decay and rust, and iron rust which is already decayed.

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Slowly the glacial soils are decaying, and, as they do so, are furnishing plant food to the water which the roots greedily draw in. So the glacial soil is not a mere store house of plant food, but a manufactory of it as well, and glacial soils are therefore "strong" and last for a long time. That decay is going on, especially near the surface, may often be seen in a cut in this kind of soil, where the natural blue color of the soil itself is seen below, while near the surface it is rusted yellow by the decay of certain minerals which contain iron.

Few materials on the earth are more important than the soil; it acts as the intermediary between man and the earth. The rocks have some substance locked up in them which animals need; by decay, or by grinding up, the rocks crumble so that plants may send roots into them and extract the substances needed by animals. Gifted with this wonderful power the plants grow and furnish foods to animals, some of them the very plant foods from the rocks; and so the animals of the land, and man himself, obtain a large part of their food from the rocks. It is then worth the while to stop for a moment and think and study about this, one of the most marvelous of the many wonderful adjustments of Nature, but so common that most people live and die without even giving it more than a passing thought.

Part II: What it Does.

BY L. A. CLINTON.

The more one studies the soil the more certainly it will be found that the earth has locked up in her bosom many secrets, and that these secrets will not be given up for the mere asking. As mysterious as the soil may appear at different times, it always is governed by certain laws. These principles once understood, the soil becomes an open book from which one may read quickly and accurately.

Uses of the Soil.

The soil has certain offices to perform for which it is admirably fitted. The most important of these offices are:

1. To hold plants in place.
2. To serve as a source of plant-food.

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3. To act as a reservoir for moisture.
4. As a storehouse for applied plant-food or fertilizer.

Some soils are capable of performing all these offices, while others are fitted for only a part of them. Thus a soil which may be pure sand and almost entirely deficient in the essential elements of plant-food, may serve, if located near a large city, merely to hold the plants in position while the skillful gardener feeds the plants with specially prepared fertilizers, and by irrigation supplies the moisture.

Early in the study of soils an excursion, if possible, should be made into the woods. Great trees will be found and under the trees will be found various shrubs and possibly weeds and grass. It will be noticed that the soil is well occupied with growing plants. The surface will be found covered with a layer several inches thick of leaves and twigs. Beneath this covering the soil is dark, moist, full of organic matter, loose, easily spaded except as roots or stones may interfere, and the soil has every appearance of being fertile.

Soil Conditions as Found in Many Fields.

After examining the conditions in the forest, a study should be made of the soil in some cultivated field. It will be found that in the fields the soil has lost many of the marked characteristics noticed in the woodland. In walking over the fields, the soil will be found to be hard and compact. The surface may be covered with growing plants, and if the seeds which have been put into the soil by the farmer have not germinated and the plants made growth, nature has quickly come to the rescue and filled the soil with other plants which we commonly call weeds. It is nature's plan to keep the soil covered with growing plants, and from nature we should learn a lesson. The field soil instead of being moist, is dry; instead of being loose and friable, is hard and compact, and it appears entirely different in texture from the woodland soil. The cause of the difference is not hard to discover. In the woods, nature for years has been building up the soil. The leaves from the trees fall to the ground and form a covering which prevents washing, and these leaves decay and add to the humus or vegetable mold of the soil. Roots are con-

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stantly decaying and these furnish channels through the soil and permit of air and water drainage.

In the field, nature's lesson has been disregarded and too often the whole aim seems to be to remove everything from the soil and to make no returns. Consequently the organic matter or humus has been used up; the tramping of the horses' feet has closed the natural drainage canals; after the crop is removed, the soil is left naked during the winter and the heavy rains wash and erode the surface and remove some of the best plant-food. After a few years of such treatment, the farmer wonders why the soil will not produce as liberally as it formerly did.

Experiment No. 1.—The fact that there is humus or vegetable mold in certain soils can be shown by burning. Weigh a potful of hard soil and a potful of lowlands soil or muck, after each has been thoroughly dried. Then put the pots on the coals in a coal stove. After the soil is thoroughly burned, weigh again. Some of the difference in weight may be due to loss of moisture, but if the samples were well dried in the beginning, most of the loss will be due to the burning of the humus.

Conditions which Affect Fertility.

There are certain conditions which affect soil fertility and of these the most important are:

Texture.
Moisture-content.
Plant-food.
Temperature.

Texture and its Relation to Fertility.

By texture is meant the physical condition of the soil. Upon good texture, more than upon any other one thing, depends the productivity of the soil. When the texture is right the soil is fine, loose and friable; the roots are able to push through the soil and the feeding area is enlarged. Each individual particle is free to give up a portion of its plant-food or its film of moisture. The conditions which are found in the woods' soil are almost ideal.

Experiment No. 2.—The importance of good texture can be

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well shown in the class-room. Pots should be filled with a soil which is lumpy and cloddy and other pots with the same kind of material after it has been made fine and mellow. Seeds should then be planted in the different pots and a careful study made of the length of time required for germination and of the health and vigor of the plants.

Experiment No. 3.—The greater part of our farming lands do not present the ideal conditions as regards texture. Clay soils are especially liable to be in bad condition. If samples of the various soils can be collected, as sand, loam, clay, etc., it may be clearly shown how different soils respond to the same kind of treatment. With a common garden trowel, the soil should be stirred and worked while wet and then put away to dry. After drying, the conditions presented by the soils should be noted, also the length of time required for the soils to become dry. Whereas the sand and the loam will remain in fairly good condition when dry, the clay will have become "puddled," *i. e.*, the particles will have run together and made a hard compact mass. Thus it is found in practice that clay soils must be handled with far more care and intelligence than is required for the sand and loams, if the texture is to be kept perfect.

Experiment No. 4.—If, in the experiment above suggested, the clay soil is mixed with leaf-mold or humous soil from the woods, it will be found to act very differently. The vegetable matter thus mixed with the mineral matter prevents the running together of the particles of clay.

Two principles, both important as relating to soil texture, now have been illustrated. Soils must not be worked when they are so wet that their particles will cohere, and organic matter or humus must be kept mixed with the mineral matter of the soil.

In practical farm operations, if the soil can be made into a mud ball it is said to be too wet to work. The required amount of humus is retained in the soil by occasionally plowing under some green crop, as clover, or by applying barn manures.

Clay soils are also frequently treated with lime to cause them to remain in good condition and be more easily tilled. Lime causes the fine particles to flocculate or to become granular, *i. e.*, several particles unite to form a larger particle and these combi-

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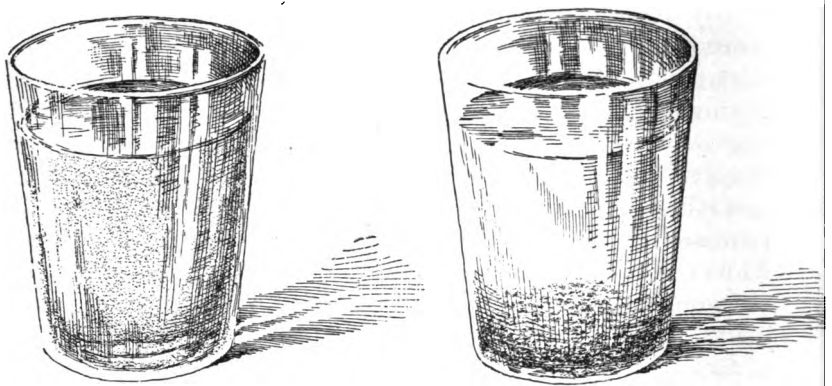
nations are more stable and do not so readily puddle or run together. A mud-puddle in clay soil will remain murky until the water has evaporated entirely. Let a little water-slaked lime be mixed with the muddy water and the particles of clay will be flocculated and will settle to the bottom and the water becomes clear.

Experiment No. 5.—Into two glasses of water put some fine clay soil and thoroughly stir the mixture (Fig. 28). Into one glass thus prepared put a spoonful of water-slaked lime and stir thoroughly, then allow both glasses to remain quiet



28.—*The glass of water at the right has received lime and the clay has been flocculated.*

that the soil may settle. Notice in which glass the water becomes clear first and note the appearance of the sediment in each.

The Moisture in the Soil.

In a former leaflet (No. 14) has been given the history of a thunder shower. We are not told much about the history of the water after it reaches the earth. If we go out immediately after a heavy shower we find little streams running alongside the road. These little streams unite to make larger streams, until finally the creeks and rivers are swollen, and, if the rain was heavy enough, the streams may overflow their banks. In all these streams, from the smallest to the largest, the water is muddy. Where did this mud come from? It was largely

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washed from the cultivated fields, and the finest and best soil is certain to start first on its voyage to the valleys or to the sea. If the farmer only had learned better the lesson from nature and kept his fields covered with plants, a large part of the loss might have been prevented. A rain gauge should be kept in every school yard, so that every shower can be measured. It can then be determined easily by the pupils how many tons of rain fall upon the school grounds, how much falls upon an acre of land, and it will be a matter of surprise that the amount is so great.

Not all the water which falls during a summer shower is carried off by surface drainage, but a considerable part sinks into the soil. As it passes down, each soil grain takes up a portion and surrounds itself with a little film of water much as does a marble when dipped into the water. If the rain continues long enough the soil will become saturated and the water which cannot be retained, will, under influence of gravity, sink down to the lower layers of soil until it finally reaches the level of the free water. From this free water, at varying depths in the soil, wells and springs are supplied. If the soil were to remain long saturated seeds would not germinate, and most cultivated plants would not grow because all the air passages of the soil are filled

29—*a. Soil too dry.* *b. Soil in ideal condition.* *c. Soil too wet.*

with water (Fig. 29). The water which sinks down deep into the soil and helps supply our wells is called free water. That portion which is held as a film by the soil particles (as on a marble) is called capillary water. After the rain is over and the sun shines a part of the moisture which is held by the particles near the surface is lost by evaporation. The moisture which is below tends to rise to restore the equilibrium, and thus there is created

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a current toward the surface, and finally into the air; and the moisture which thus escapes aids in forming the next thunder storm.

Experiment No. 6.—Humus enables the soil to take up and hold large quantities of water. To illustrate this: Two samples of soil should be obtained, one a humus or alluvial soil, rich in organic matter, and the other a sandy soil. Put the two samples where they will become thoroughly air dry. Procure, say five pounds each of the dry soils, and put into glass tubes over one end of which there is tied a piece of muslin or fine wire gauze. From a graduated glass pour water slowly upon each sample until the water begins to drain from the bottom of the tube. In this way it can be shown which soil has the greater power of holding moisture. Both samples should then be set away to dry. By weighing the samples each day it can be determined which soil has the greater power of retaining moisture. This experiment can be conducted not only with sand and humus, but with clay, loam, gravel and all other kinds of soil.

Experiment No. 7.—A finely pulverized soil will hold more film-moisture than a cloddy soil. To illustrate the importance of texture as related to moisture, soil should be secured which is cloddy or lumpy. One tube should be filled as heretofore described (Exp. No. 6.) with the lumpy soil, and the other tube with the fine soil which results from pulverizing the lumps, equal weights of soil being used in each case. From a graduated glass pour water upon each sample until the drainage begins from the bottom. Notice which soil possesses greater power of absorbing moisture. Put the samples away to dry, and by carefully weighing each day it can be determined which soil dries out most readily.

The prudent farmer will take measures to prevent the escape of this moisture into the air. All the film-moisture (on the soil particles) needs to be carefully conserved or saved, for the plants will need very large amounts of moisture before they mature, and they can draw their supply only from this film-moisture. We can again apply the lesson learned in the woods. The soil is there always moist; the leaves form a cover or blanket which prevents the evaporation of moisture. Under-

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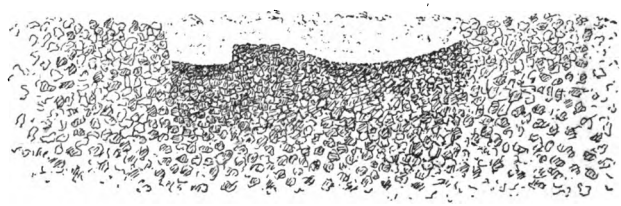
neath an old plank or board, the soil will be found moist. If we can break the connection between the soil and the air we can check the escape of moisture. A layer of straw over the soil will serve to prevent the loss of moisture. But a whole field cannot be thus covered. It has been found that by keeping the surface soil loose, say about three inches of the top soil, it can be made to act as a blanket or covering for the soil underneath. While this top layer may become as dry as dust, yet it prevents the escape by evaporation of moisture from below. It is a matter of common observation that if tracks are made across a freshly cultivated field the soil will become darker where the

30.—"*Foot-prints on the sands of time.*"

tracks are (Fig. 30). This darker appearance of the soil in the foot-marks is due to the moisture which is there rising to the surface. The implement of tillage makes the soil loose and breaks the capillary connection between the lower layers of soil and the surface and the upward passage of the water is checked. Where the foot-print is, the soil has been pressed down again at the surface, the particles have been crowded closer together and capillarity is restored to the surface and the moisture is free to escape (Fig. 31). In caring for flower-beds, or even in growing plants in a pot in the school-room, it is important that the surface of the soil be kept loose and mellow. Far better is a garden rake in a flower garden than a watering pot.



31.—*A cross section through one of the foot-prints.*

Experiment No. 8.—To show the importance of the surface mulch, fill several pots with a sandy loam soil, putting the same

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weight of the same kind of soil into each pot. In one pot pack the soil firmly; in another pot pack the soil firmly and then make the surface loose. These pots of soil may then be put away to dry, and by weighing each daily it can be readily determined what effects the various methods of treatment will have upon the moisture-holding power.

Experiment No. 9.—This experiment may be varied by covering the soil in some of the pots with leaves or straw or paper, care being taken that the added weight of the foreign matter be properly accounted for.

Soil Temperature.

If a kernel of corn be placed in the ground in early spring before the soil has become warm, the seed will not germinate.

32.—*The moss-grown lawn or grass plot.*

Abundance of moisture and oxygen may be present, but the third requisite for germination, proper temperature, is lacking. The soil is very slow to become warm in the spring, and this is due to the large amount of water which must be evaporated. During the winter and spring the rain and melting snow have saturated the soil. The under-drainage is deficient and there is no way for the escape of the surplus water except by evaporation, and evaporation is a cooling process. A well drained soil is thus warmer.

The atmosphere is much quicker to respond to changes in temperature than is the soil. In the spring the air is warm while the soil continues cold and the rains which fall during this time are warmed by passing through the warm air, and in sinking through the soil the water parts with some of its heat and the soil in made warmer. During mid-summer the soil becomes very

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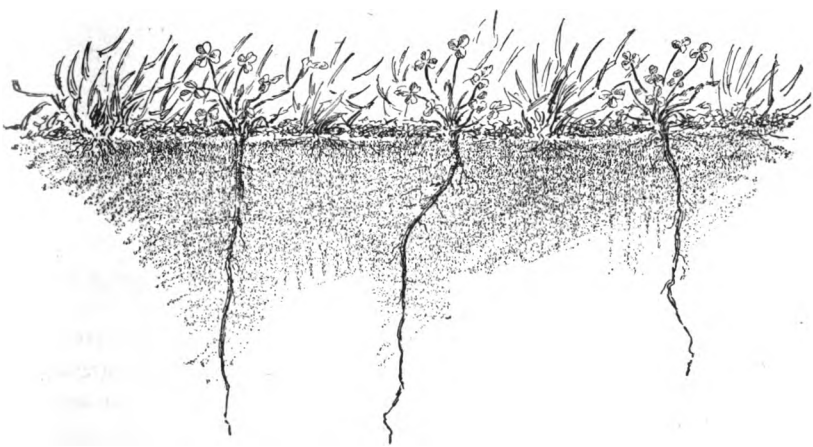
warm and it is not affected by cool nights, as is the atmosphere. Consequently a summer rain may be several degrees cooler than the soil, and in passing through the soil the water takes up some of the heat, and the soil conditions are made more favorable for plant growth. Therefore, soil temperature is regulated somewhat by the rainfall.

Experiment No. 10.—The color of a soil also affects its temperature, a dark soil being warmer than a light colored soil. By having thermometers as a part of the school room equipment, interesting experiments can be conducted in determining the effect of color and moisture upon the temperature of soils.

Air in the Soil.

While that part of the plant which we can see is entirely surrounded by air, yet it is necessary that the soil be in such a con-



33.—*The clover roots penetrate the soil deeply.*

dition that it can be penetrated by the air. Indeed, growth cannot begin in a soil from which the air is excluded.

Experiment No. 11.—To prove this, put clay soil in a pot, plant seeds and then wet the surface of the soil and puddle or pack the clay while wet and watch for the seeds to germinate and grow. At the same time put seeds in another pot filled with loose, mellow, moist soil.

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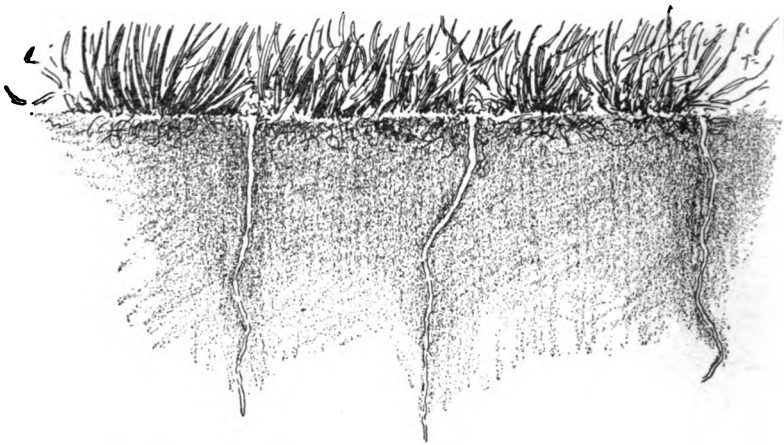
Frequently after the farmer has sown his grain there comes a heavy, beating rain, and the surface of the soil is so packed that the air is excluded and the seeds cannot germinate. If plants are grown in pots and the water is supplied at the top of the soil it may become so hard and compact as to exclude the air and the plants will make a sickly growth. The surface soil must be kept loose that the air can penetrate.

On many lawns it is noticed that the grass is not thriving. It has a sickly appearance and even the application of fertilizer



34.—*After the clover dies the soil is in better condition for their having lived.*

does not seem to remedy the conditions. Perhaps the ground has become so hard the air cannot penetrate and the grass is being smothered. If the surface of the soil can be loosened with a garden rake, and clover seed sown, much good may be accomplished. The clover is a tap-rooted plant, and sends its main root deep into the soil.

After the death of the plant the root decays, the nitrogen which is stored up can be used as food by the other plants, and most useful of all, in such cases, the decay of the tap-root of the clover makes a passage deep into the soil and thus allows the air to enter. Consult Figs. 32–34.

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STEALING A RIDE.

PART I. SIR BUR, TRAMP AND TRAVELER.

BY MARGARET FURSMAN BOYNTON.

"Chick-a-dee-dee-dee dee-dee" sounded from the hedge. I caught the motion of the little feathered food-gatherers but could not see a a single black-capped head.

"Chick-a-dee-dee-dee-dee-dee, Come and play with me-me-me-me-me." With such an invitation how could I help going out into that brilliant, blue and golden mid-winter day? Against the clearest of skies each tiny bud-tipped maple twig glowed ruddily. The mountain ash berries still hung in bright clusters, crowned with light pyramids of fluffy snow. The deserted nests in the orchard recalled the busy householders of the warmer, leafier seasons and a few withered apples offered scanty nourishment to solitary wayfarers. Under my feet the snow spread a creaking carpet, and all about me it afforded a background of diamonds for the devious patterns of the shriveled weeds showing clear and fantastic against it. What a joyous day for the chick-a-dees and me!

Presently, attracted by the regiment of teasels there encamped, I turned aside into a small common, a vacant lot well within the borders of our small city, and I tramped it over rejoicing in the short skirt and leggins that permitted unhampered wading in the snow. There were many things to be seen in that little area. Bitter-sweet berries draped the fence. Ragged miniature umbrella skeletons recalled the filmy, white parasols of the wild carrot in its summer guise. "Devil's pitchforks" and bristling burdocks plucked at my skirt in passing, and a few hoary aster heads still lingered amid the star-tipped stems whence most of the feathered parachutes had flown. A kindly farmer caught me shaking the teasel heads and called cheerily "I guess you've got a kind of a putterin' job there, ain't ye?" and

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charitably took me into his bob-sleigh for the short half mile back to my corner; but he was not a nature-student and did not know what fun I had been having. Nor could he know that the handful of brown and withered stuff that formed the trophy of my half hour's trip would offer me a juicy cud to chew.

Prominent in my winter bouquet were several sprigs of burdock with rigid stems and bristling burs (Fig. 35). If you, too, want to hear the story Sir Bur will tell under questioning you can probably find the material in plenty on the nearest waste land or in a fence corner, or by the roadside.

35.—*Burs of the Burdock. One-third natural size.*

You, as well as I, in all likelihood, made bur baskets and furniture, and even people richly garbed in green and purple, all your childhood days; yet did you ever stop to think how the burs stick so pertinaciously? Why they should? And what they do for the plant? No, even the tormenting little boy from across the road who made use of their valuable properties in ornamenting your long hair with bunches of burs probably could not have told you why they were so effective.

Notice first, then, the numerous tiny hooks bristling in every direction (Fig. 36). How abrupt is the curve of each hook, how smooth and polished the outer surface! It will push readily between the finest and closest fibers. How sharp is the incurved point! See, it has penetrated your skin, as you press the bur lightly between your fingers! The slender shanks of the hooks yield readily to pressure only to gain more tenacious hold. In disentangling one you are caught by five. The stems all stand stiff and rigid, holding the burs unyieldingly in your way and adding to the advantage of the flexible hooks. Your clothing brushes a bur ever so lightly, the fibres at the base break readily and away your bur travels; and not singly usually, for note how the branches have so grown,

36.—*Burdock hook.*

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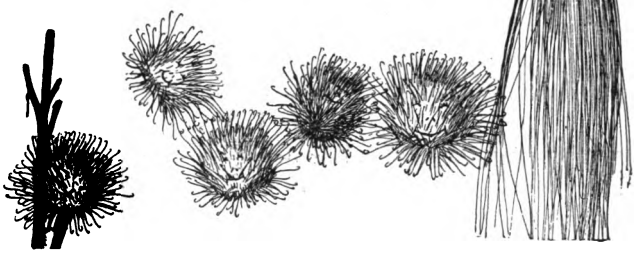
the lower ones lengthening, that the burs are practically clustered by twos and threes and fours, with hooks interlacing, and they go together. So, clinging with a score or two of little hands to the hair of some passing animal or the clothing of a human tramp, Sir Bur steals many a long ride, often relaxing his hold only by going to pieces. The tail of the old cow carries them over the fields (Fig. 37).

38.—*The burdock akene.*

This then is *how* he travels, but *why?* What good does the journey secure for the plant?

Tear a bur apart and find within, among the short twisted bristles, hard little brownish-gray bodies, almost like miniature Brazil nuts (Fig. 38), that are —what? If you have not thought you will say seeds, for they look like seeds. But are all seed-like bodies properly so called? Where do these little fellows come from?



37.—*Burs stealing a ride.*

If you have studied the flower in general, you will remember that its important parts in view of its office of reproduction are the *stamens* which produce the pollen and the *pistil* with its *ovary* or seed-case. Within the ovary grow the small bodies which develop into the seeds. Further, the ripened ovary with whatever parts may consolidate with it in development, and with the matured seeds contained, is called the fruit. That is to say, we name things in natural history not alone from appearance and function or office, but according to their origin and development.

What then have we in the bur, seeds or fruits?

You would not think of calling a pea pod a seed would you? You know if you stop to consider that each pea is a seed, and the pod with its peas is the fruit, because developed from the minia-

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ture pod in the blossom which was the ovary, and contained the ovules or young seeds. Similarly you easily distinguish morning-glory seeds from its fruits, the nasturtium seeds from the fruits. In all these cases and in hundreds of others the fruit is a pod and opens at maturity to let the seeds escape, but there are also hundreds of kinds of plants in which the ovary ripens with a single seed inside of it and does not open at maturity. In this case the fruit is usually but little larger than the contained seed and often looks like a seed itself. However that be, a single-seeded dry fruit that does not open at maturity is called an *akene*. Akenes are what we find in the bur.

How do I know? How can *you* tell in other cases? Unfamiliar akenes found away from the parent plant might not be so easily detected, for the single seed within is not always readily found free from the ovary walls, but it can usually be identified by its relation to the plant. You remember that the *seed* is borne *within the ovary*. The pea pod and the morning glory and nasturtium pods you know were closed up tight to the time of maturity. But this bur never was nor could have been closed, evidently. In all probability then it is not an ovary. What then? The purple color of our young bur was borne, we remember, at the top of each bur. These blossom tops, we can think out now, were masses of pinky-purple flowers, each bur containing many small flowers. The whole is called a compound flower. Each of the little brown wrinkled fruits within the bur is an *akene*, the fruit of a single flower. Perhaps we shall find crowning some of the akenes the withered remains of the flowers. The tiny blossom was one of several that grow inside the big bur; and each little blossom makes, or tries to make, an akene.

Of course the seed within the akene germinates and produces a new plant just as any other seed does. Because of Sir Bur's adroitness at stealing rides, the new little burdock plant usually finds its chance at greater or less distances from its parent plant, and reaps much the same advantage as any pioneer. In favorable circumstances it finds freedom from the competition of its kind, that is, it does not have to struggle with its fellows for the same

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food-stuffs, the same conditions of growth and health. It has room.

Indeed, it is because of his traveling powers that Sir Bur is here at all, for his race originated in Europe. He was not in New England to greet the pilgrims, as they left Plymouth Rock, nor in the south to welcome the Virginian settlers. His earliest immigrant ancestors possibly came in the Mayflower, but more probably took stowaway passage some time later in the tail of some dog or sheep brought from across the sea. However he came, he is here, numerous and widespread as you know him, and he is still traveling, the veriest tramp of the roadside, stealing rides and pressing ever onward toward the west, following the trail of man and his domesticated animals.

Part II. The Red Cow and the Maple Tree.

BY JOHN W. SPENCER.

The day was so warm as to suggest an oven. The rays of the sun came the most direct way—as a boy would make a bee-line cross-lots. A blue haze hung about the heavens, dimming the sun at midday and at sunrise and at sunset, making it look like an immense orange, and the heated air shimmered across the level pasture. It was one of those days that warps the slivers in the plank walk and makes prickly the path of the barefooted boy—a day when most boys want to go to the swimming hole at the bend of the creek under the leaning beech.

On a gravelly knoll a sleek red cow stood in the dark, thick shade of a maple tree. A colony of persistent flies was clinging to her shoulder and scattering ones flew about her ears, and others would have found a resting place on her hips and back but for the incessant switching of her tail. With all the persistent switching, the cow, with half closed eyes, chewed her cud with the regularity of the swinging of a pendulum.

Said the Red Cow to the Maple Tree, "You have no troubles such as I have. See how I am pestered with flies every hour of the day. Flies do not trouble you."

Said the Maple Tree to the Red Cow, "It is fortunate they do not for I have no tail with which to switch them."

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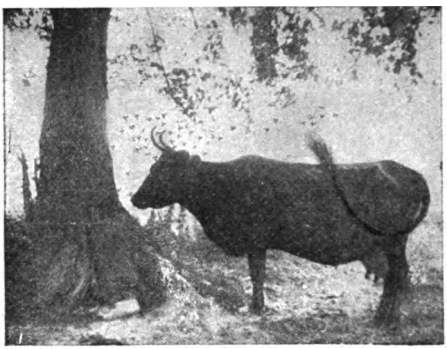
Said the Red Cow to the Maple Tree, "I am very thirsty and I shall not find a refreshing drink until, while on my way to the barn to be milked this evening, I shall wade through the brook."

Said the Maple Tree to the Red Cow, "You complain because you have to walk for a drink of water. Is that not better than to long for it and be obliged to wait until it comes to you from the clouds? All of us plant-fellows in this neighborhood need water badly, and some whose roots do not extend deep into the soil have sufferd unto death. It is for this reason that the grass has famished and you no longer find a nearby lunch as you found it earlier in the season. I would, indeed, consider it a privilege to travel all day, if I could then have a refreshing drink. But alas! when I made this spot my home, it was to be the only place I should ever live during all my life. Food is as difficult for me to obtain as water. In the earlier part of the season when rains were more plentiful, you found a daily lunch within a stone's throw of this spot; but now when there is nothing here to your liking, you are able to wander to any part of the pasture in search of the best food. I must content myself with what I can find in this one spot. When a drouth comes, like the present one, and there is not enough moisture to satisfy my thirst, nor to float sufficient plant-food to my roots, I must endure a double suffering —thirst and hunger. In the cold weather you can seek the warm and sunny side of a straw stack, while I must stand out here on this bleak and unprotected knoll with the winds of winter whistling through my bending limbs."



39.—*The red cow.*

"I should not complain," continued the Maple Tree, "for Nature is kind to us all, and we can see her kindness if we look for it in the right way. She has provided blessings for us

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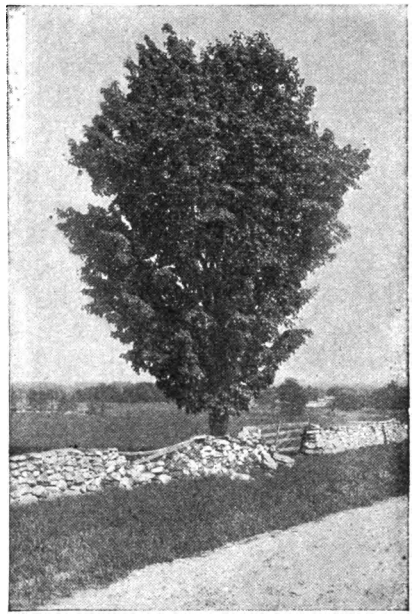
all, but not of the same kind or in the same way. She has planned that plants never move their homes; that where they make a start in life, there they must remain. She affords all plants great opportunities, however, for sending their chileren abroad in large numbers and gives them means for traveling long distances. In this way many are sure to find congenial places for a life of prosperity. I have no fear that maples will ever become extinct. Some years I send out so many children that if one in every thousand becomes a tree, my family will be a large one.



40.—*The maple tree.*

"Do you see the big thistle in yonder fence corner? The children are now mature and ready to travel miles and miles in a balloon, and will settle down into some quiet nook and become plants. The farmer, who calls them weeds, has been fighting them for a life time; but, although he is able to keep them from making serious encroachments upon his crops, the thistle will always be with him. It is abundantly able to take care of itself. Were it not for the sharp needles on the leaf, a red cow might have swallowed them long ago.

"See those dark clouds forming in the west—wool sacks they are called. Hark! Did I hear thunder? If a red cow fears being struck by lightning, she had better hasten to the bars at the end of the pasture and call to be put into the barn. I hope we shall have a shower. If even some crumbs from it should fall this way, it would be a comfort to me."

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NOTES FOR JUNIOR NATURALISTS.

A BULB GARDEN.

"It's rather dark in the earth to-day."
Said one little bulb to his brother;
"But I thought that I felt a sunbeam ray—
We must strive and grow till we find the way!"
And they nestled close to each other.
Then they struggled and toiled by day and by night,
Till two little snowdrops in green and white,
Rose out of the darkness and into the light,
And softly kissed one another.—*Boston Journal.*

PART I. A TALK BY UNCLE JOHN.

BY JOHN W. SPENCER.

To succeed with the cultivation of flowers, the first thing to have in mind is to make the plant comfortable. This condition should be not only the first thought, but also the last thought. If you can do this successfully, the plant will do the rest of the work and your results will be abundant.

What plant comfort is, is a question more easily suggested than answered, for it is a very large subject—about as large

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as the surface of the earth. As a guess we will say that there are as many different kinds of plants as there are people. It is at least safe to say that plants have as many different notions as to their conditions of life as have the people of the different nations and tribes of the world.

If you were to have a birthday party and should invite as your guests the children from the four corners of the earth, and by magic could bring them to you in a jiffy, the boys and girls from Greenland would come en- folded in seal skin, and those from Hawaii would bring only their bath- ing suits. You would have a busy time keep- ing them com- fortable, for when you open- ed the door to cool off the little Greenlanders, the little Kana- kas would com- plain of too much draft; and at table the for- mer would ask if you happened to have some tallow candles for dessert, and the latter would ask for bread- fruit and bana- nas.

41.—*The Snow-drop.*

Many of our flowering plants have been brought togeth- er from such remote quarters as that. We have bulbs from Holland, and pansies from England, and phlox from the dry atmosphere of Texas.

There is as much difference in the conditions necessary for comfort in these different plants as there is in the requirements of the little Eskimos and little Polynesians. To some extent, plants can change their manner of living, but in the main they are happiest when they can have their own way, just as you and I are.

We cannot bring about the foggy, damp weather of Holland and England when we want it, neither can we bring the dry atmosphere of Texas—air so dry that meat will cure hard in

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the hottest weather without tainting. It so happens, however, that from one Fourth of July to the next we have many kinds of weather, and if one could not find conditions suited to almost any kind of plant it would be strange. If we cannot make the weather accommodate itself to the best comfort of the plant, we must set the plant so as to accommodate itself to the weather.

Pansies from foggy England and bulbs from the lowlands of Holland should be planted to bloom in the cool days of spring, and the phlox from Texas will be quite happy in the heat and drought of July and August.

With this idea well fixed in your mind, you will easily see that when you know the country from which a plant has come, a knowledge of the physical geography of that country will be helpful in knowing how to make the plant happy and prosperous.

We must also make the plant comfortable in the soil. There is great difference in what plants require to make them comfortable. Some, like thistles or mullein or ragweed, will thrive on almost any soil and are no more exacting as to food than a goat or a mule; but other plants are as notional as children reared in the lap of luxury.

As a rule, flowering plants belong to the "lap-of-luxury" class. Elsewhere in this number you are told how nature has developed soil. I hope you will read the article carefully, for there you will understand that all earth is not soil. Soil covers the land as thin skin covers an apple or as you would spread a thin coat of butter over bread, and it holds more or less plant-food.

When men erect school buildings and afterwards grade the ground they usually turn a part of the soil upside down. There is also considerable rubbish of the builders left scattered about, such as brick-bats, chips of stone, and the like, that go to make the place an uncomfortable one for notional plants. For this reason I wish particularly to call your attention to the manner in which you should prepare the ground on which you intend to plant. The first thing to do is to spade the soil very thoroughly to the depth of at least ten inches. All stones as large a big boy's fist should be thrown out, and all lumps given a bat with the back of the spade to make all the particles fine. This is to be a flower bed and should be soft like your own bed. It

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would be better to make it up more than once. After the first spading it would be well to cover the bed with a coat of stable fertilizer to a depth of six to eight inches, which will give additional plant-food; and in spading the second time, this fertilizer will become thoroughly mixed with the soil. The surface should next be raked smooth, and your flower bed will then be ready for planting.

We all admire the bright bulb flowers that are among the first to blossom in the spring. These mostly come from Holland, or at least attain their perfection there. We have just spoken of the importance of planting flowers at such a time that they may live their career when our climate is most like that from which they come. In the case of bulbs, spring and early summer is the most favorable time for them in this country, and fall is the proper time for planting.

The exact time in the fall to plant, how to plant, what bulbs to plant, when to put a winter overcoat on the bed, and other details, we will leave for Mr. Hunn to tell. He has had many years' experience in the management of flowers, and we advise you to read carefully what he says.

Part II. A Talk by the Gardener.

BY C. E. HUNN.

Your Uncle John has told you something about preparing a bed for your plants. His advice is very good; but the bulbs we are to talk about are like those notional children whom he mentions and they do not want tallow candles for any part of their meal.

What I mean is that bulbs do not want to come in direct contact with the stable fertilizer, but they want it down below them where the feeding roots that grow out of the bulb may nibble at it when the bulb is hard at work developing the leaves and flower. You know that all the leaves and the flowers were made the year before, and the bulb simply holds them until the new roots have formed. No kind of treatment will make a bulb produce more flowers than were formed in the year it grew (last

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year); but the better the treatment, the larger and finer the flowers will be.

If I wanted to make a bulb bed, I should choose, if possible, a sandy soil and throw out the top soil to the depth of six inches. Then I should put into the bottom of the bed about two inches of well rotted manure and spade it into the soil. Then I should throw back half of the top soil, level it off nicely, set the bulbs firmly on this bed and then cover them with the balance of the soil; in this way you will have the bulbs from three to four inches below the surface. It is dark down there and in the fall months the top of the ground is cooler than at the depth of five or six inches and the top of the bulb will not want to grow, while the bottom which is always in a hurry will send out roots, to push out the leaves and flowers the next spring.

When the weather is cold enough to freeze a hard crust on the soil, the bed should have its winter overcoat. This may be straw, hay, cornstalks or leaves spread over the bed to the depth of six inches if the material is coarse; but if you use leaves, three inches will be enough, because the leaves lie close together and may smother out the frost that is in the ground and let the bulbs start. What we want is to keep them asleep until spring, because if they start too early the hard freezes of March and early April will spoil their beauty if the leaves or flowers are near or above the surface. Early in April the covering may be removed gradually and should all be off the beds before the leaves show above the ground.

Perhaps many of you cannot find a sandy place for your beds; if not, make your beds as has been told you, leaving the stones in the bottom of the bed for drainage. Then, when you are ready to set the bulb place a large handful of sand where your bulb is to go and set your bulb on it; this will keep the water from standing around the bulb. Very fine results may be had on heavy soil by this method.

What kind of bulbs shall we put into these beds? Select hyacinths, tulips, narcissus or daffodils, with snowdrops or crocuses of various colors around the edge.

If you use hyacinths you can have the national colors, red, white and blue, or many shades of either color, as shown in the

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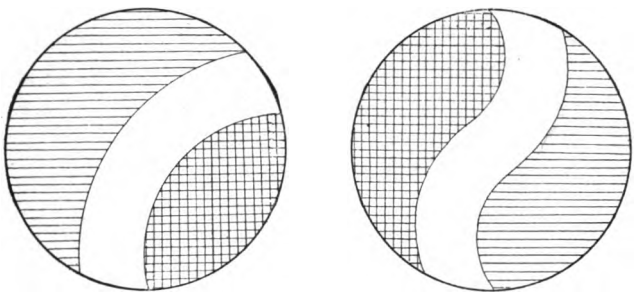
diagrams (Figs. 42). Of tulips you can have stars or ribbons of yellow, white or crimson, or in fact almost any color except true blue. In narcissus, yellow, sulfur and white are the colors. The little crocuses come in yellow, blue, white and striped colors, and are in bloom and gone before the large flowers take your attention. Many other bulbs are fine for spring flowering but as most of them are more difficult to grow and



42.—*Simple designs for bulb beds.*

many of them rather expensive, I do not think we will discuss them now.

Suppose we want a bed of red, white and blue hyacinths (Figs. 42), and make it six feet in diameter. How many bulbs would you want? Now, hyacinths should be planted six inches apart each way, and the outside row should be at least three inches from the edge of the bed. You see you will want a little over one hundred bulbs, which if one person had to buy would cost him or her quite a little; but if fifty or more boys and girls would club together it would be easy for everyone, especially if, after making out a list of all the bulbs you want, you were to write to one of the dealers in bulbs telling him what you want, and how you except to enjoy the flowers, asking him to let you have them as cheaply as possible. You will find that he will be glad you are interested in bulb growing, and be surprised how cheaply he will let you have them.

It you want a bed of tulips, they should be planted four or five inches apart instead of six inches, so you will need more bulbs; but they are cheaper than hyacinths. The narcissus bulbs being still smaller than tulips, may be planted three inches

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apart; and the little crocuses, the first flower of spring, should touch one another, as should also the snowdrops.

Perhaps many of you do not wish to wait until spring for your bulbs to flower, in which case we must try to persuade them to bloom through the winter, say at Christmas. Nearly all bulbs are good natured and may be coaxed to do things that nature never asks them to do; so if we go at it right we will find it very easy to make them think their time to bloom has come, even if the ground is covered with snow and the ice is thick on the ponds. Hyacinths, narcissus and crocus all can be made to flower in the winter by starting this way. Get the bulbs so as to be able to pot them by the middle or last of October, or if earlier all the better. The soil should be rich, sandy loam if possible; if not, the best you can get, to which add about one-fourth the bulk of sand and mix thoroughly. If ordinary flower pots are to be used, put in the bottom a few pieces of broken pots, charcoal or small stones for drainage, then fill the pot with dirt so that when the bulbs are set on the dirt the top of the bulb is even with the rim of the pot. Fill around it with soil, leaving just the tip of the bulb showing above the dirt. If the soil is heavy a good plan is to sprinkle a small handful of sand under the bulb to carry off the water the same as is done in the beds outdoors. If you do not have pots you may use boxes. Starch boxes are a good size to use as they are not heavy to handle, and I have seen excellent flowers on bulbs planted in old tomato cans. If boxes or cans are used, care must be taken to have holes in the bottoms to let the water run out. A large size hyacinth bulb will do well in a five-inch pot. The same size pot will do for three or four narcissuses or eight to twelve crocuses.

After the bulbs are planted in the pots or other receptacles, they should be placed in a cool place, either in a cold pit or cellar or on the shady side of a building or, better yet, plunged or buried up to the rim of the pot in a shady border. This is done to force the roots to grow while the top stands still; as only the bulbs with good roots will give good flowers. When the weather gets cold enough so a crust is frozen on the soil, the pots should be covered with a little straw, and as the weather gets colder

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more straw must be used. In from six to eight weeks after planting the bulbs, they should have made roots enough to grow the plant, and they may be taken up and placed in a cool room for a week or so, after which, if they have started into growth, they may be taken into a warmer room where they can have plenty of light. They will grow very rapidly now and will want lots of water, and after the flowers begin to show, the pots may stand in a saucer of water all the time. When just coming into bloom the plants may have full sunlight part of the time to help bring out the color of the flowers. Fig. 43 shows a pot of tulips.

43.—*Pot of tulips.*

I want to tell you of two bulbs that do not need so much fussing to get them to bloom for Christmas. One of them is called freesia (Fig. 44) and if I could have but one kind of bulb to flower in the winter, I would choose this. The little bulbs are not half as large as crocus bulbs and you will be astonished at the large leaves and flowers such a bulb can produce. The bulbs are about the cheapest of all winter bulbs and they grow without putting them away to make roots, as the tops do not seem as impatient to start as most other bulbs, but wait until there are plenty of roots to help them along. The flowers are borne on a slender stem and look very graceful, either on the plant or in bouquets. They are also very fragrant and a pot with five or six bulbs will perfume a large room. All they need is good light soil, sunlight, water and warmth to make glad the heart of anyone who plants them.

The other bulb I would select is the Oriental narcissus or Chinese Sacred lily. This grows in water without any soil whatever. Just take a bowl or glass dish about three times the size of the bulb; put some pretty stones in the bottom; set in

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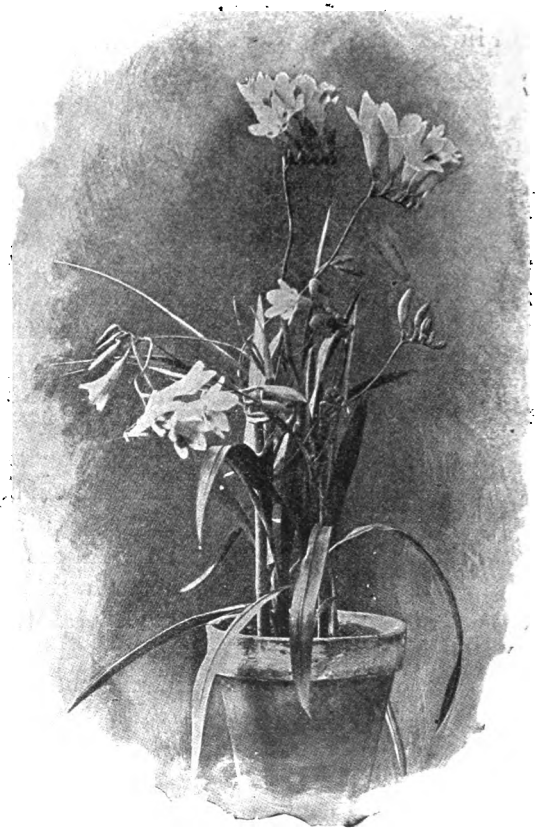
the bulb and build up around it with stones so as to hold it stiff when the leaves have grown; tuck two or three small pieces of charcoal among the stones to keep the water sweet, then fill up the dish with water and add a little every few days, as it evaporates. Set the dish in a warm, light place. In about six weeks the fragrant, fine white flowers will fill the room with perfume and you will have had the pleasure of watching the roots start and grow, the top throw up long green leaves and the flower spikes develop and open their flowers. Hyacinths may also be grown in water, but not as easily as this narcissus, or in such inexpensive dishes.



44.—*Pot of the freesia.*

The picture (Fig. 45) of a bulb box was taken last winter from a box of mixed bulbs grown at Cornell. The calla in the center and the Kenilworth ivy trailing over the front of the box were

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planted in the box in September, and pots of geraniums and other plants set on the dirt to fill the space. When the bulbs that were in pots were ready to be started they were taken out of the pots and set in the dirt in the box where they grew and flowered; the

45 — *Winter box of bulbs.*

tall stems are Paper White narcissus, the last variety for winter. On each side there is a hyacinth just starting and in front a little freesia in bloom. When these bulbs were done flowering, small pots of blooming plants were set on the box and a charming window box was had with many different things in it through the winter.

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CLUB NOTES.

We must have a yell for the Junior Naturalist Clubs. What shall it be? We shall be very glad if each of you send us something for that purpose, and we will make a selection. Let it be something the girls can yell as well as the boys.

***

The new school year brings a change of teachers to our Junior Naturalist Clubs of last spring. Our plan is to have clubs that organized last spring retain their charters and reorganize under the new teacher. Some of the former members may drop out, but we hope new members will take their places.

***

Our club buttons are now ready for distribution and will be sent to each of our old members as soon as their clubs reorganize under their new teachers, and to members of our new clubs as soon as they show an interest by paying the fortnightly dues.

***

Whenever your Uncle meets in public a boy or girl wearing a Junior Naturalist Club button, he will speak to the wearer without any formality; and he thinks it a good plan if members will do the same thing. Let us feel that we belong to the same fraternity and all have the same interest in nature, and we will be friends to each other. He wishes to encourage a feeling of friendship among members of different clubs. When convenient, it will bring good results for one club to visit another, and the host club can show the guest club what it is doing in the study of nature.

***

Your Uncle is always glad to receive your photographs either in groups or singly. He has a number on hand now and will welcome more. Next to meeting you boys and girls is the sight of your shadows, for that is what a photograph means.

***

Your Uncle wishes to speak to you about the letters he receives from his friends, the Junior Naturalists. At one time last spring

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the number was about two hundred each day. Every one of these was read. The ones written as payment of club dues were sorted out and given to a department where the letters, after a close reading, were passed to the credit of the writer. Those of a personal nature or asking information concerning some nature-study topic were handed to your Uncle for his perusal, and for him to answer, so far as he could. Do not think that any of your letters are thrown away without being read.

***

Your Uncle is anxious that each of you boys and girls shall receive his personal attention. With such a large number of letters you must be thoughtful and helpful, and he asks you to send your letters and drawings, that go as dues, in one envelope under the direction of the secretary of your club, and be addressed BUREAU OF NATURE-STUDY, CORNELL UNIVERSITY, ITHACA, N. Y. He hopes that you will feel like writing him freely, and in your natural way, all about your difficulties in your investigations as naturalists, and he wishes you to tell him of some of the bright things that come into your lives, and some of the shadows, too, if there are any such. All such should be addressed to JNO. W. SPENCER, DEPUTY CHIEF, BUREAU OF NATURE-STUDY, CORNELL UNIVERSITY, ITHACA, N. Y.

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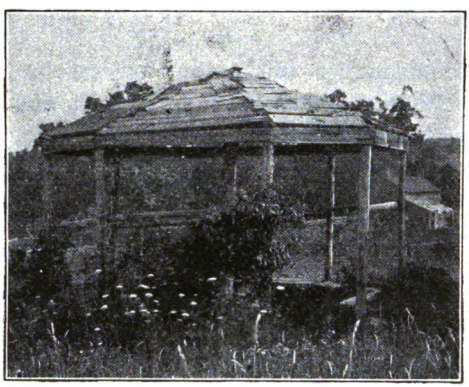
We are often asked—"Will it not answer your purpose of dues just as well if we send you a few samples?" No, it will not by any means. A record of the work done by each boy and girl is kept in our department on a card, and we want the communications of every member so that proper credit can be given.

* * *

The inquiry is not infrequent—"What do you do with the thousands of letters in the form of dues sent each month?" We are glad to assure all Junior Naturalists that each letter received in payment of dues is handled with great respect and proper credit given on each card.

* * *

The Junior Naturalist family now numbers more than 21,000 boys and girls. They live in many states; and there is one club in Egypt and another in Tasmania.



A Junior Naturalist Club House.

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D. L. Bunnell

DEC [illegible]
GIFT

January, 1900.

CORNELL

NATURE-STUDY QUARTERLY

No. 3.

Teacher's Leaflet no. 16

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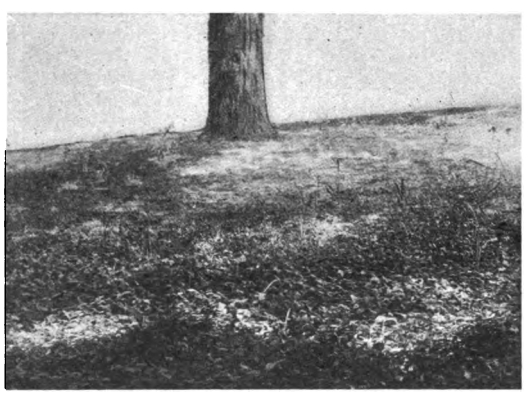
HOW PLANTS LIVE TOGETHER.

L. H. Bailey.

TO THE general observer, plants seem to be distributed in a promiscuous and haphazard way, without law or order. This is because he does not see and consider.

The world is now full of plants. Every plant puts forth its supreme effort to multiply its kind. The result is an intense struggle for an opportunity to live.

Seeds are scattered in profusion, but only the few can grow. The many do not find the proper conditions. They fall on stony ground. In Fig. 94 this loss is shown. The trunk of an elm tree stands in the background. The covering of the ground, except about the very base of the tree, is a mat of elm seedlings. There are thousands of them in the space shown in the picture, so many that they make a sod-like covering which shows little detail in the photograph. Not one of these thousands will ever make a tree.



94.—*A carpet of young elms, all of which must perish.*

Since there is intense competition for every foot of the earth's

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surface that is capable of raising plants, it follows that every spot will have many kinds of plant inhabitants. Plants must live together. They associate. They become adapted or accustomed to each other. Some can live in shade: they thrive in the forest, where sun-loving plants perish. Others prefer the sun, and thereby live together. There are plant societies.

95.—*A plant society waiting for the spring.*

Every distinct or separate area has its own plant society. There is one association for the hard tramped door-yard,—knotweed and broad-leaved plantain with interspersed grass and dandelions; one for the fence-row,—briars and choke-cherries and hiding weeds; one for the dry open field,—wire-grass and mullein and scattered docks; one for the slattern roadside,—sweet clover and ragweed and burdock; one for the meadow swale,—smartweed and pitchforks; one for the barnyard,—rank pigweeds and sprawling barn-grass; one for the dripping rock-cliff,—delicate bluebells and hanging ferns and grasses. Indefinitely might

96.—*Weak, narrow-leaved grasses grow in the cat-tail forest.*

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these categories be extended. We all know the plant societies, but we have not thought of them.

In every plant society there is one dominant note. It is the individuality of one kind of plant which grows most abundantly or overtops the others. Certain plant-forms come to mind when one thinks of willows, others when he thinks of an apple orchard, still others when he thinks of a beech forest. The farmer may associate "pussly" with cabbages and beets, but not with wheat and oats. He associates cockle with wheat, but not with oats or corn. We all associate dandelions with grassy areas, but not with burdocks or forests.

It is impossible to open ones eyes out-of-doors, outside the paved streets of cities, without seeing a plant society. A lawn is a plant society. It may contain only grass, or it may contain weeds hidden away in the sward. What weeds remain in the lawn? Only those which can withstand the mowing. What are they? Let a bit of lawn grow as it will for a month, and see what there is in it. A swale, a dry hillside, a forest of beech, a forest of oak, a forest of hemlock or pine, a weedy yard, a tangled fence-row, a brook-side, a deep quiet swamp, a lake shore, a railroad, a river bank, a meadow, a pasture, a dusty roadway, — each has its characteristic plants. Even in the winter, one may see these societies, — the tall plants still asserting themselves, others of less aspiring stature, and others snuggling just under the snow (Fig. 95).

97.—*The wild grape covers the tree-top, and the children play in the bower. The grape is searching for light.*

Often these societies are in the nature of overgrowth and undergrowth—one society living beneath another. Of such are forest societies. Few woods are so dark that some plants do not grow on the ground, unless they are evergreen or coniferous

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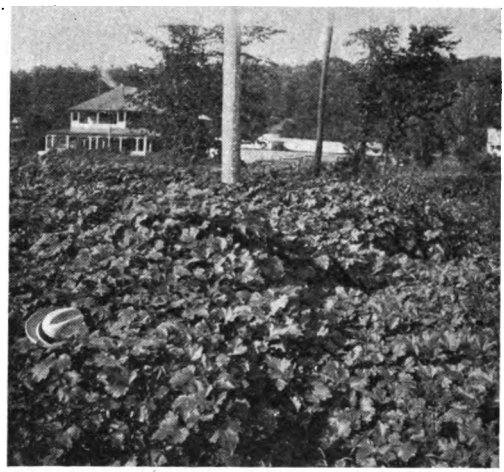
woods. Even in humbler communities, the overgrowth and undergrowth are usually apparent if one looks closely. Separate the cat-tails in the dense swamp and see the weak and narrow-leaved grasses growing between (Fig. 96). Note the clover, young grasses and other plants between the grass in the meadow: the farmer says that his meadow has good "bottom."

Some plants even grow on top of other plants. It is their way of getting light. Of such are the climbers. Note the mantle which the wild grape throws over the trees (Fig. 97). Often the supporting tree is smothered and killed.



98.—*A colony of clotbur.*

When an area is newly cleared, many plants rush for it. Quickly it is covered with ambitious growths,—pokeweeds, fireweeds, thistles, briars, nettles. Often each plant occupies large places alone, making clumps or patches. These patches are plant colonies,—made up mostly of one species or kind (Fig. 98). But as the struggle tightens, other plants insinuate themselves into the colony and it is broken up; a mixed population results. Sometimes these colonies are broken up by the shade of trees and tall bushes which have come up near them, for all neglected areas, in this part of the world, tend to return to forest if they are not mowed, pastured or burned. Mowed and pastured areas run into grass, for the grass withstands the cutting and grazing. In burned areas the struggle begins anew when the fire has passed.

Plant societies are easy of study by the school. Their study appeals to the desire of exploration and adventure, and it adds zest to the excursion. Go to a swale, swamp, roadside, forest,

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weedy field or other place, and ask the pupil to note : (1) that the flora of the place is unlike that of places with different physical features ; (2) that these particular plants grow together

99.—*Two plant societies,—the close-bitten sward and the rushy pond.*

because they all can survive under similar conditions; (3) what these conditions are,—whether sun, shade, dry soil, wet soil,

100. *The edge of the road. Trees and bushes crowd the drive-way, and a ribbon of grass and weeds has pushed itself to the very margin.*

sand, clay, rock ; (4) what particular plant is most abundant or gives character to the society.

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Study one society thoroughly. Make lists of the kinds of plants and of the relative numbers of each. If the names of the plants are not known, call them by numbers; make dried specimens of them for reference. When another society is visited, repeat these observations, and compare one society with another.

Ask every plant why it grows there.

NOTES.

It is not yet too late for the planting of spring bulbs, as crocus, hyacinth, narcissus and others. Our Quarterly No. 2 contains directions for the work. A reprint of these directions can be had by making application for it.

* * *

The autumn colors and the mode of falling of leaves are suggestive topics for nature-study in the late fall.

* * *

The autumn is a season of activity with birds. They are flocking and preparing for their southern journey. Bright plumage is not so often seen as in the spring. A large proportion of the individuals are young and they lack the rich colors of the adults, or they have the sober dress of the female. Some of the old birds, as the male bobolink and scarlet tanager, have donned more inconspicuous garbs and are less visible to their enemies while on their southern journeys. The autumn has many kinds of birds. Besides our permanent residents like the chickadee, nuthatch, bob-white and other species which remain at all times, there still linger after the nesting time many migrating summer birds to feed on fruits, seeds and grain. Among the migrants are most of our warblers, such small thrushes as the olive-back and hermit, and many sparrows including the sweet-voiced white-throat. The great majority of our aquatic birds, and a few birds of prey, are migrants.

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GIFT

January, 1901.

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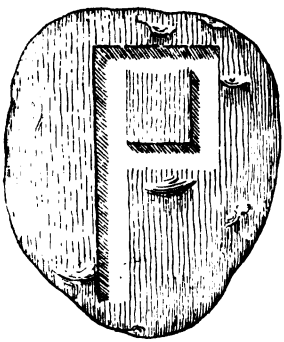
A HILL OF POTATOES.

I. P. ROBERTS.



PLANT a hill of potatoes. You can do it in the school-room. Plant in a box or a flower-pot. Keep the box warm, and do not let the soil dry out. Plant whole tubers and pieces of tubers. Plant pieces of various sizes. Plant some that have no "eyes." Plant shallow—so that the tuber is just covered with soil—and deep. Watch the results.

All plants are abundantly supplied with means for reproducing their kind: some by seed, some by multiplication at the crown or base or by roots, others by means of underground stems; and some, as the potato, have two or more means of reproduction. In its wild or partially improved state the potato is abundantly supplied with fruit, "seed balls," borne on the top of the stalks. The seeds of a single ball often will produce many varieties of potatoes and they cannot be depended upon to reproduce the parent stock. Farmers seldom attempt to raise potatoes from the seeds; when they do it is for the purpose of securing new varieties. The common method of reproduction is to plant a part or all of an enlarged underground stem, that is, a part of the "potato" or tuber.

When the soil is reasonably porous and fertile, a strong root may start at the seed piece and descend more or less directly into the subsoil. In most cases, however, the roots spread laterally. This is a good illustration of how plants may vary in their root habits in order to adapt themselves to their environment. Notice where the roots form on the plants you are growing. Few farmers know where they form. Distinguish the true or feeding roots from the underground stems. Determine how many

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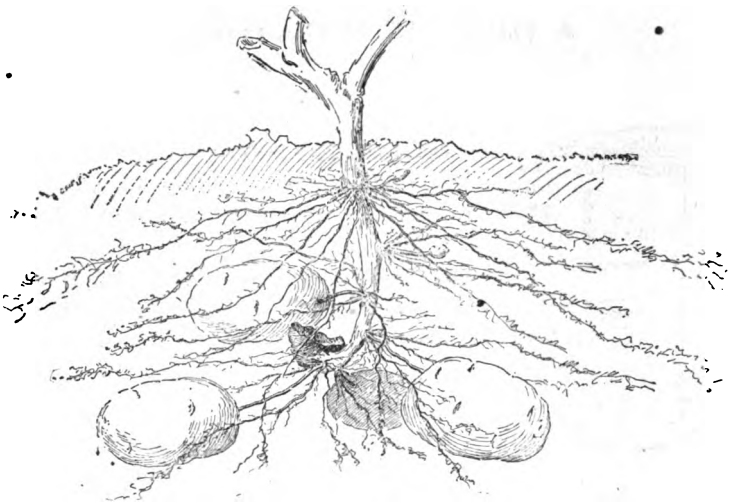
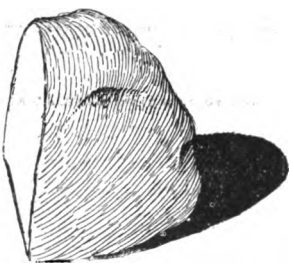
tubers form on each underground stem. Dig up a hill of potatoes from the garden before school closes.



101. *Underground part of potato plant in mellow soil.*

A single eye, with a portion of the tuber attached to furnish nourishment to the bud until sustenance can be secured from newly formed rootlets, may produce one, occasionally more, strong upright stems. A most interesting study of manifold reproduction may be made even in the winter time by planting in a fertile soil a piece of potato containing a single eye. As soon as the rootlets begin to start, divide each eye and piece into two parts and re-plant. In a few days after the rootlets have again started, divide the two pieces into four and re-plant. This operation may be performed again and again, until many plants suitable for transplanting in the open may be secured from a single eye.



102. *Piece of tuber for planting, bearing a single ey*

Demonstrate that the potato contains starch. This can be done by applying a drop of dilute iodine to a freshly cut surface of the

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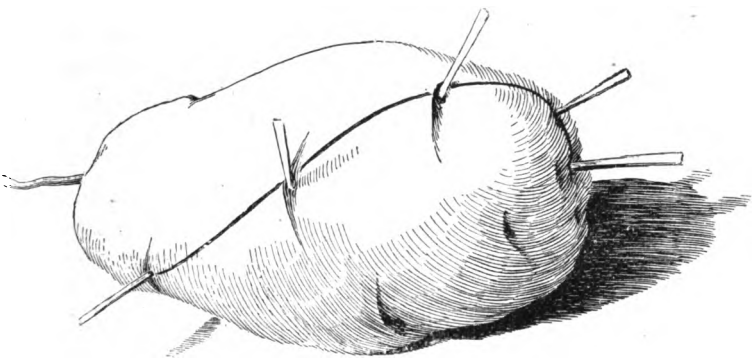
tuber: the starch grains turn blue-black. Five cents worth of iodine purchased at the drug store will be sufficient for many tests. Dilute it about one-half with water. This starch, after being changed to sugar, supplies the young plant with nourishment. Dig up the pieces you have planted and see which start first, shoots or roots.

The "potato" is an enlarged underground stem provided with numerous buds similar to those on the stems of plants above ground. These buds are placed spirally on the underground stem or tuber with a considerable degree of uniformity.



103. *How to illustrate the spiral arrangement of the eyes.*

As on the stems of other plants, the buds are less numerous and weaker at the base and most numerous and vigorous at the top or upper end. On a smooth well developed long potato, the spiral arrangement of the buds may be illustrated by sticking a tooth-pick or pin in each eye, beginning at the base or stem end, and connecting the pins with a string.

Farm notes on the potato.

Having seen the potato growing in the school room, some information may be given respecting its treatment in the field as a crop.

Potatoes are easily raised, even under adverse conditions, although they respond quickly to superior fertility and tillage. The average yield in the United States during the last ten years

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was 76.6 bushels per acre, although from three to four hundred bushels per acre are not uncommon under superior tillage when soil and climate are at their best.

The area devoted to potatoes during the last decade was two and a half million acres annually. Potatoes do best on a moderately moist and deep soil and in a climate relatively cool.

Since the period of growth is short, varying from three to five months, they should be planted in soil which has an abundance of readily available plant food. Notice in Fig. 101 that most of the underground stems which have produced potatoes leave the main stem about four inches below the surface and but a short distance above the seed-piece. This suggests that the seed should be planted about four inches deep. To produce three hundred bushels of potatoes requires the exhalation of over three hundred tons of water: therefore water or moisture is of quite as much importance in securing large yields as plant food.

It is best to prepare the land deeply, to plant deep, and then to practice nearly or quite level culture. The practice of hilling up potatoes, so common in most parts of the country, is to be discouraged, because it is wasteful of moisture and the tubers do not grow in the coolest part of the soil. For very early potatoes, hilling-up may be allowable. Till the soil very often to save the moisture. For the philosophy of this, see Leaflet No. 15.

Not infrequently the potato is seriously injured by blights which attack the leaves. The early blight, which usually appears in June, may destroy some of the foliage, thereby checking growth. The late blight, which also attacks the foliage, is far more serious. It differs little in outward appearance from the early blight. In rare cases the vines are so seriously injured that no potatoes are formed. The potato rot or blight did great damage to the potato in many localities in the United States in 1845. In 1846 the blight appeared in Ireland and virtually destroyed the entire crop. Previous to this date the potato had become the chief food supply of the peasantry. The cultivation of the oat as a food crop had been universal previous to the introduction of the potato, but oats furnished so little food on a given area as compared to the potato that its cultivation at the time the blight appeared had

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been very largely abandoned. The loss of the potato crop produced widespread famine. The most conservative estimate of the numbers who perished for want of food or by disease caused by a meager diet of unhealthy and innutritious food is set down at six hundred thousand during the two years of the potato blight. This disease was not so destructive in 1847 as in 1846 and by 1848 it had virtually disappeared. Some one has said that if Great Britian had expended one dollar for investigating the diseases of potatoes where she has spent a thousand dollars for perfecting the engines of war, the terrible famine might have been averted. We now think it a relatively easy matter to keep the blight in check by thorough spraying with Bordeaux mixture.

How the potato has been improved.

All plants have their origin in pre-existing plants. While the young plant is always similar to the one from which it was derived, it is never exactly like it in every detail. This arises from the fact that all of the conditions under which the parent plant and its offspring grow are never exactly alike. The variations or differences in the plants are usually exceedingly small in a single generation, but occasionally they are wide, in which case they are called "sports" and are usually difficult to perpetuate. If successive generations of plants are reared under continuously improved conditions, there will be a continuous and accumulating variation from generation to generation, which in time may come to be so great as to make it difficult to discover a marked similarity between the wild and cultivated forms of the same plant.

When conditions are undisturbed by man there is found to be a fierce struggle for existence, the hardiest or those best suited to the conditions preponderate, and this without any reference to the wants of mankind. The farmer steps in and selects those plants which give promise of being most useful or most beautiful and then decreases or eliminates the struggle for these selected plants, by destroying the plants which are least desirable, by fertilizing and tilling the soil, by conserving moisture and by improving the physical conditions of the land, thereby

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making it more comfortable for the plants which he has chosen. The selected or "improved" plant, by reason of being more comfortable and better nourished, tends to vary in one or more directions from the wild and unimproved types. Whenever these variations tend towards greater productiveness, better quality or enhanced beauty, selection is again made of such specimens as give promise of supplying the wants and gratifying the desires of civilized man. The bettered conditions of the plant, by reason of man's effort, do not usually result in producing like variation along all lines. One part of the plant as the flower, the fruit or the stem, varies more than the other parts. All this tends to break up a single type or stock into many varieties. There are hundreds of varieties of potatoes all traceable to a single wild species. The kind and quantity of nourishment supplied plays the most important part of any single factor in producing variation.

The general character of the cultivated potato plant as to leaf, stem, root and habit of growth, is virtually the same as the wild plant, variation having been directed and accentuated along the line of increasing the size and quality of the underground tubers. This habit of producing enormously enlarged stems has been operating so long that the plant has inherited the power of transmitting this acquired quality to the succeeding plants. The most improved varieties seldom produce seed balls because growth has been directed so largely toward enlarging and multiplying the tubers. By selecting tubers with buds not fully developed and avoiding those with deep, sunken eyes, varieties have been produced with few eyes or buds and these set not in deep indentations but nearly even with the surface of the potato.

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NOTES FOR THE TEACHER.

We trust it will be your pleasure to plant some potato tubers in your schoolroom and also to make the iodine test for starch as has been suggested on pages 188, 189. Or, better still, have your pupils plant them, under your supervision. Such experiments will give them a forceful illustration of two principles that pertain to all life: Provision for the future (or for welfare of offspring), and excellent methods for attaining such plans. The motive of the potato, if we may so speak, is to make the most of its opportunity for attaining the greatest perfection and also for perpetuating its kind. The manufacture of starch, and storing a quantity for future use, are important factors towards these ends.

That a plant should prepare for its own welfare and also make provision for the offspring seem to place it almost on the plane of having intelligence. That the industrious honey bee shows such foresight is commonly known and the example has long been held up for man's imitation. Why should not the potato be held in similar admiration? If plants were not provident for their future, the world would have an empty cupboard and the full dinner-pail would be a meaningless expression.

We wish to say a word about the philosophy of cooking the potato. At first sight the dust-like specks of starch may seem too insignificant for much consideration, but you can impress on your pupils that the grains they see are on the surface only, and that great numbers of other starch grains lie next underneath, and that the aggregate in a good sized potato is very great. If they ask why a raw potato is not as good food as a raw apple, you can explain that each of the starch grains in the potato is covered with a film which offers a strong resistance to the digestive organs of man, but not necessarily of cattle or horses. By heat the starch grains are popped open as heat pops open a kernel of corn. They will easily understand how a kernel of popped corn is more digestible than a raw kernel. You can judge best whether to tell your pupils that the part of food known as carbohydrates maintains the animal heat of the body. Starch is

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one of the carbohydrates. There is another element of food in the potato not shown by the iodine test. It is called protein, which makes blood and muscle. One reason why potatoes cook better when placed in hot water instead of in cold water, is that the sudden heat coagulates the protein of the surface and retards the entrance of water through the mass of the potato and thus tends to make them cook less "soggy." Some potatoes, however, cook "soggy" even with the greatest care on the part of the cook. This coagulation also prevents the extraction of the protein from the interior of the potato. This same principle is illustrated in the best method for cooking beefsteak. When the surface is quickly seared by heat there is a coagulation of the protein at that point of the steak that prevents, as we say, "the escape of the juices."

JNO. W. SPENCER.

***

Planting a plant will be the subject of our solicitude this spring. We want every Junior Naturalist to plant something, if it is nothing more than a potato. How many children under 14 years ever planted a plant of their own and cared for it during a season? Soon we shall issue a leaflet on the subject. In the meantime be thinking about interesting the children in planting something.

***

The Teachers' Home Nature-Study Course is to be improved and enlarged. Heretofore we have not been able to give it the attention that it deserves. Now we are ready to push it. We want you to coöperate with us. We shall publish a monthly lesson. Any teacher in New York State may enroll. Our Farmers' Reading Course has over 20,000 readers. We wish that our Teachers' Course were as large.

***

The days are lengthening. Before we are aware, there will come a soft and velvet spot in the winter days, known as the February thaw. The streams will be bank-full of roistering, swirling water. The ice will be tilted along the brook-margins, and the sleighing will be patchy. Then we shall wait for the first vision of the robin and for the "disembodied voice" of the

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bluebird. Then will come the epidemic of "spring fever." The disease is "catching."

Try to direct the spring energies of the pupil into resourceful lines of work. Be prepared for the "burst of spring." Look up questions of birds, bird houses, aquariums, and breeding-cages. Always connect the schoolroom observations with the things as they exist in the fields. Whenever possible, begin the observations in the field rather than in the house. We shall be glad to give suggestions.

***

With the return of the spring enthusiasm is the time to push the organization of Junior Naturalist Clubs. Have you organized Clubs in your grades? You will find that the clubs will aid you in maintaining interest and discipline in the regular school work. We will attend to all the detail of the correspondence, and thereby relieve you of any feeling of responsibility. If you contemplate organizing a club, write us for particulars and instructions. In the State of New York there is no expense to either teachers or pupils.

***

We desire to keep in the closest possible touch with our many thousand teachers. If you have attempted any nature-study work, we should like to know what your successes and failures have been. Tell us what subjects you find to be the best for your conditions. Mention the ages of the children.

***

We hope that at some time you have studied twigs. See our Leaflet on "Four Apple Twigs." The winter twig records an astonishing range of history. If your pupils have studied twigs in the schoolroom, it is then a good plan to assign each one a twig on a tree or bush. Allow the twig to remain on its plant, label it, and then let the children watch it as the buds swell and the leaves come out. On the first warm day, let them make a drawing and description of the twig while it is still in its winter dress.

L. H. Bailey, Chief of Bureau of Nature-Study.
John W. Spencer, Deputy Chief.

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A STUDY OF FISHES.

H. D. REED.

THE first forms of animal life which attract the young naturalist's attention are doubtless the birds. These are most interesting to him because of their beautiful colors, their sweet songs and the grace with which they fly through the air. But who has watched the fishes in a brook or an aquarium and is not able to grant them a place, in beauty, grace and delicate coloration, equal to the birds? To be sure fishes cannot sing, but there are so many other interesting facts in connection with their habits and life-histories that it fully makes up for their lack of voice.

The parts of a fish.

While observing a living fish and admiring its beauty, it will probably occur to some of us that a fish consists only of a head and tail. But this is not all. Between the head and tail is a part that we may call the trunk. It contains the digestive and other organs. There is no indication of a neck in a fish. Any such constriction would destroy the regular outline of the animal's body and thus retard the speed with which it moves through the water. But head, trunk and tail are not all. There are attached to the outer side of the fish's body certain appendages that are called fins.

Before discussing some of the different kinds of fishes and their habits, it will be necessary to learn something about fins, for the fins of all fishes are not alike. When a fish moves through the water, it bends its tail first to one side and then to the other. This undulatory movement, as it is called, pushes the fish's body ahead. One can observe the movements easily upon a specimen kept alive in an aquarium jar. At the extreme

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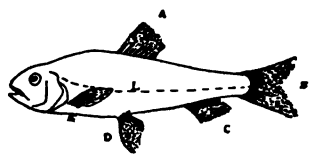
end of the tail there is a broad, notched fin which aids the tail in propelling and steering the body. We will call this, the *tail* or *caudal* fin (Fig. 104, B). In most of our common fishes there are seven fins,—six without the caudal. The first of these six is a large fin situated near the middle of the back. This is the *back* or *dorsal* fin (Fig. 104, A). Sometimes we may find a fish that has two dorsal fins. In this case the one nearest the head is called first dorsal and the next one behind it, the second dorsal. Near the head, in a position corresponding to our arms, is a pair of fins which are called the *arm* or *pectoral* fins (Fig. 104, E). Still farther towards the tail, on the under side of the fish, is another pair, corresponding in position to the hind legs of a quadruped. This pair is called the *leg* or *pelvic* fins (Fig. 104, D). Just behind the pelvic fins is a single fin, situated on the middle line of the body. This is the *anal* fin (Fig. 104, C). The pectoral and pelvic fins are called paired fins because they are in pairs. The others which are not in pairs are called median fins, because they are situated on the middle line of the body. The paired fins serve as delicate balancers to keep the body right side up and to regulate speed. They are also used to propel the body backwards. After naming the different fins of the fish, in the schoolroom aquarium, it will be interesting to observe the uses of each.



104.—*Diagram of a fish to show: A, dorsal fin; B, caudal fin; C, anal fin; D, pelvic fins; E, pectoral fins; L, lateral line.*

On the side of the body, extending from the head to the caudal fin, is, in most fishes, a line made up of a series of small tubes which open upon the surface. This is called the *lateral line*, and acts in the capacity of a sense organ (Fig. 104, L). Is the lateral line straight or curved? Does it curve upwards or downwards? Does the curvature differ in different kinds of fishes? Do all the fishes you find possess a lateral line? Is the lateral line complete in all fishes,—i.e., does it extend from the head to the caudal fin without a single break?

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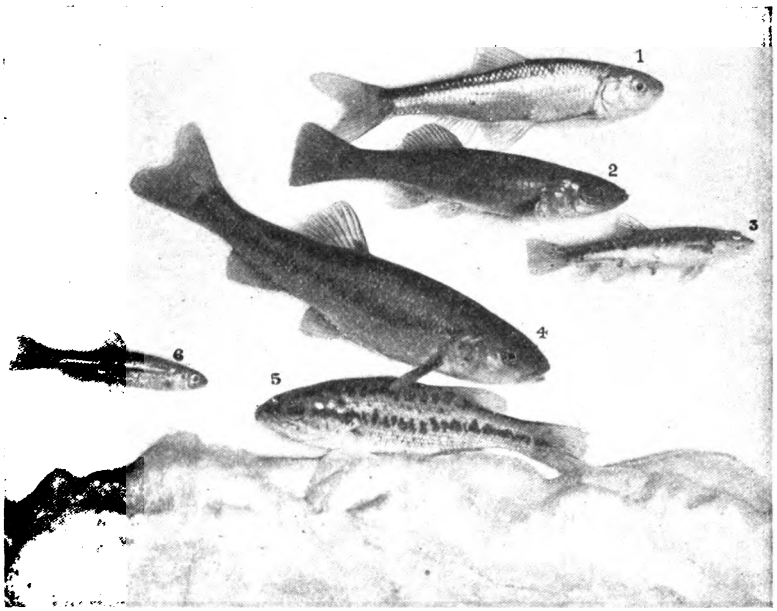
Where fishes spend the winter.

As winter approaches and the leaves fall and the ground becomes frozen, the birds leave us and go farther south into warmer climates where food is more abundant. We are all familiar with this habit of the birds, but how many of us know or have even wondered what the fishes have been doing through the cold winter months while the streams and ponds have been covered with ice? Before the warmth of spring comes to raise



105.—*1, Shiner; 2, Barred Killifish; 3, Black-nosed Dace; 4, Creek Chub; 5, Young of Large-mouthed Black Bass; 6, Varying-toothed Minnow.*

the temperature of the streams, let us go to some familiar place in a brook where, during the summer, are to be found scores of minnows. None are to be found now. The brook shows no signs of ever having contained any living creatures. Suppose we go farther up or down the stream until we find a protected pool the bottom of which is covered with sediment and water-

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soaked leaves. With our net we will dip up some of the leaves and sediment, being sure that we dip from the very bottom. On looking over this mass of muddy material we may find a fish two or three inches long, with very fine scales, a black back, a silvery belly and a blackish or brown band on the side of the body extending from the tip of the nose to the tail. This is the *Black-nosed Dace* (Fig. 105). If specimens of this fish are caught very early in the spring, one will be able to watch some interesting color changes. As the spawning time approaches the dark band on the sides and the fins change to a bright crimson. Sometimes the whole body may be of this gaudy color. During the summer the lateral band becomes orange. As the season goes, the bright colors gradually fade until finally, in the fall and winter, the little black-nose is again clothed in his more modest attire. A great many of the fishes, and especially the larger ones, seek some deep pond or pool in the stream at the approach of winter, and remain near the bottom. If the pond or stream is so deep that they do not become chilled, they will remain active, swimming about and taking food all winter. But when the stream is very shallow and the fishes feel the cold, they settle down to the bottom, moving about very little and taking little or no food. The carp collect in small numbers and pass the winter in excavations that they make in the muddy bottom. If the débris thrown up by the water across the marshy end of a lake be raked over during the winter, one will probably find some of the smaller catfishes spending the season in a semi-dormant state.

Some interesting experiments may be tried with the fishes in the aquarium jar. Keep them for a few days where it is cold and then bring them into a warmer room and note the difference in their activity.

The common Catfish or Bullhead.

This sleepy old fellow differs in many respects from most of our common fishes. He has no scales. About the mouth are eight long whisker-like appendages, called barbels (Fig. 106). Perhaps he is called catfish because he has whiskers about his mouth like a cat. Anyone who has ever taken a catfish from the

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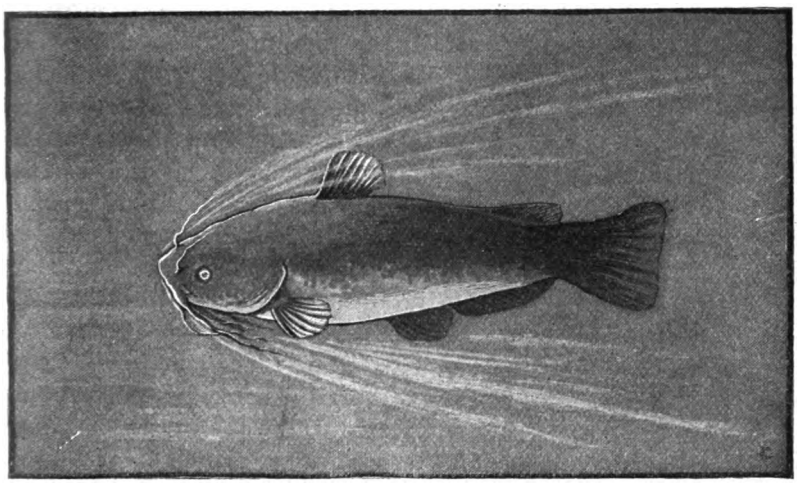
hook probably knows that care is needed in order not to receive a painful prick from the sharp spines in his pectoral and dorsal fins.

There is nothing aristocratic about the catfish. In warm pools and streams where the water is sluggish and the muddy bottom is covered with weeds, he may be found moving lazily about in search of food. His taste is not delicate. Animal substance, whether living or dead, satisfies him. When in search



106.—*The common Catfish or Bullhead.*

of food he makes good use of his barbels, especially those at the corners of his mouth which he uses as feelers. The catfish will live longer out of water than most of our other food fishes. They will live and thrive in water which is far too impure for "pumpkin seeds" or bass. They spawn late in the spring. The mother fish cares for her young much as a hen cares for her chickens. When they are old enough to take care of themselves, she weans them.

The common Sun-fish or Pumpkin Seed.

Some evening just at sunset visit a quiet pool in a nearby stream. Drop in your hook baited with an "angle worm" and presently the dancing cork shows that you have a "bite."

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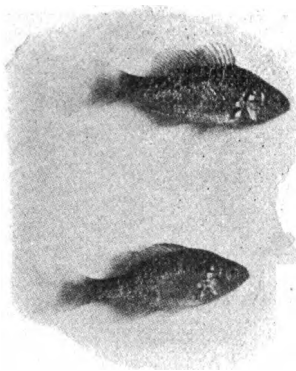
On "pulling up" you find that you really have a fish. It is a beautiful creature, too,—thin flat body shaped something like the seed of a pumpkin. His back is an olive green delicately shaded with blue. His sides are spotted with orange, while his belly is a bright yellow. His cheeks are orange-color streaked with wavy lines of blue. Just behind his eye on his "ear-flap" a bright scarlet spot. This is the common *Sun-fish* or *Pumpkin Seed* (Fig. 107). He is a very beautiful, aristocratic little fellow, "looking like a brilliant coin fresh from the mint."



107.—*The common Sun-fish or Pumpkin-seed.*

Keep him alive in an aquarium jar with a shiner. Compare the two fishes, as to the size and shape of their bodies and fins. Feed them different kinds of food, such as worms, insects and crackers, and try to discover which they like best and how they eat.

The sun-fishes prefer quiet waters. They lay their eggs in the spring of the year. The female selects a spot near the banks of the stream or pond where the water is very shallow and contains an abundance of water plants. Here she clears a circular area about a foot in diameter. After making an excavation of three inches or more in the gravel or sand, the nest is completed. The eggs are then deposited in the basin-like excavation. She watches her nest and eggs with great diligence, driving away other fishes that chance to come near.

The Black Basses.

The black basses are not usually found in small streams where it is most pleasant for teachers and pupils to fish. They are fishes which seek the rivers and lakes. There are two kinds of black bass, the *Large-mouthed* and the *Small-mouthed*. As the name indicates, the two may be distinguished by the size of the mouth. In the large-mouthed black bass, the upper jaw extends to a point behind the eye, while in the small-mouthed

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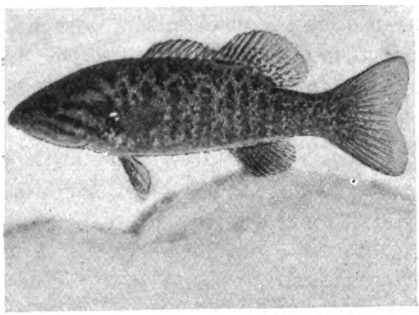
species it extends to a point just below the middle of the eye (Fig. 108).

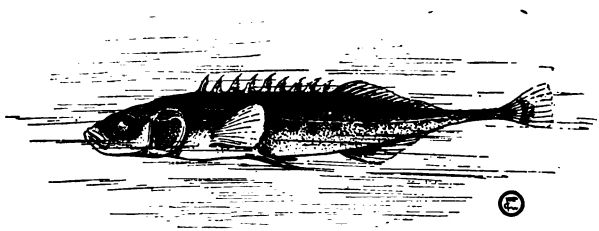
Both kinds of black bass may be found in the same body of water. The character of the bottoms over which they are found, however, differs. The small-mouthed prefers the stony bars or shoals. The large-mouthed, on the contrary, selects a muddy bottom grown over with reeds. They feed upon crayfish ("crabs"), minnows, frogs, worms, tadpoles and insects. Our black basses are very queer parents. They prepare a nest in which the eggs are deposited. Both male and female are very courageous in the defence of their eggs and young. As soon as the young fishes are able to take care of themselves the parent fishes leave them, and after that time may even feed upon their own children.



108.—*Adult Small-mouthed Black Bass.*

The Stickleback.

The sticklebacks are queer little fellows indeed (Fig. 109). The slender body, extremely narrow tail, and the sharp, free spines in front of the dorsal fin, give them at once the appearance of both an active and a pugnacious little creature. The sticklebacks are detrimental to the increase of other fishes since they greedily destroy the spawn and young of all fishes that come within their reach. They build nests about two inches in diameter, with a hole in the top. After the eggs are laid the male defends the nest with great bravery. The little five-spined



109.—*A Stickleback.*

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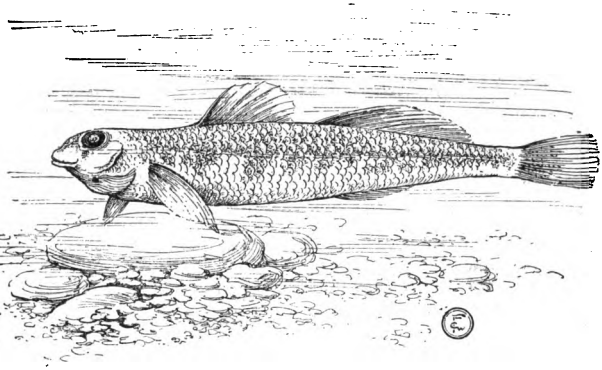
brook stickleback in the Cayuga Lake Basin, N. Y., is most commonly found in stagnant pools, shaded by trees, where the water is filled with decaying vegetable matter,—the so-called "green frog-spawn" (spirogyra), and duck weed. If you supply the sticklebacks with plenty of fine vegetable material, you may induce them to build a nest in the aquarium jar, but they must be caught and placed in the jar early in the season before they spawn.

The Johnny Darters.

In New York State, every swift stream which has a bed of gravel and flat stone ought to contain some one of the Johnny darters, for there are a great many different kinds (Fig. 110). They are little creatures, delighting in clear water and swift currents where they dart about, hiding under stones and leaves, or resting on the bottom with their heads up-stream. The body of a darter is compact and spindle-shaped, gradually tapering from the short head to a narrow tail. The eyes are situated nearly on top of the head. The color of the darters varies greatly with the different kinds. Some are very plain, the light ground color being broken only by a few brown markings. Others are gorgeous in their colorings, it seeming as if they had attempted to reproduce the rainbow on their sides. Such kinds are indeed very attractive and are ranked with the most beautifully colored of all our common fishes. When a darter swims, he appears bird-like for he flies through the water much as a bird flies through the air. He does not use his tail alone in swimming, as the catfish, the sunfish, the stickleback, and most of the other fishes do, but flies with his pectoral fins.



110.—*A Johnny Darter.*

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You surely must have a Johnny darter in your aquarium jar. The Johnnies are true American fishes. Though small, they face the strong currents and eke out a living where their larger cousin, the yellow perch, would perish. There are many interesting facts which may be learned from the Johnny darters when kept alive in an aquarium. When not actually moving in the water, do the Johnnies rest on the bottom of the jar or remain suspended in the middle apparently resting on nothing as the other aquarium fishes do? When a fish remains still in the middle of the jar, he does so because he has a well-developed air-bladder to help buoy him up and when a fish dies it is the air-bladder which causes him to turn over and rise to the top. Now if the Johnnies always rest on the bottom of the jar when not swimming and if one happens to die and does not rise to the top we may know that, if he has an air-bladder at all, it is only a rudimentary one. It would be interesting also to find out for ourselves if a Johnny darter can really "climb trees." (I mean by trees, of course, the water plants in the aquarium jar), or if he can perch upon the branches like a bird.

The Minnows.

All the small fishes of the brooks are called minnows, or more often "minnies," by the boy fisherman. The boy believes that they grow into larger fishes. This is not true. The minnows are a distinct group of fishes and, for the most part, small ones. They do not grow to be bass or pike or sunfishes or anything else but minnows. Some of the minnows, however, are comparatively large. Two of these are the *Creek Chub* (Fig. 105), and the *Shiner* (Fig. 105). The chub is the king of the small brooks, being often the largest and most voracious fish found in such streams. His common diet probably consists of insects and and worms, but if very hungry he does not object to eating a smaller fish. During the spawning season, which is springtime, the male chub has sharp, horny tubercles or spines developed upon the snout. We are able to recognize the Creek chub by means of a black spot at the front of the base of the dorsal fin.

The shiner or red-fin has much larger scales than the chub. The back is elevated in front of the dorsal fin, giving him the

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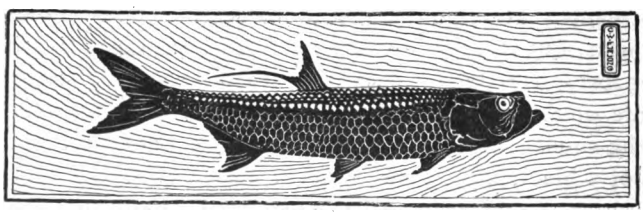
appearance of a hump-back. His sides are a steel-blue with silvery reflections. While the shiner is not the largest, it is almost everywhere one of the most abundant brook fishes. In spring the lower fins of the male become reddish. Like the chub, he has small horny tubercles developed on the snout.

Random notes.

Did you ever see a fish yawn? Watch a shiner in your aquarium. Sometimes you may see him open his mouth widely as though he was very sleepy. Again you may find him resting on the bottom of the jar taking a nap. Fishes cannot close their eyes when they sleep for they have no eyelids.

A convenient way to collect fishes for the schoolroom aquarium is to use a dip net. The ordinary insect net will do but it is better to replace the cheese-cloth bag by a double thickness of mosquito-bar, thus enabling one to move the net through the water more rapidly. By dipping in the deep pools, among grasses and under the banks with such a net, one can soon obtain fishes enough to stock an aquarium (Fig. 111). The aquarium jar should never be placed in the sun. It is better to have only three or four fishes in an aquarium at one time. Some flat stones on the bottom of the jar will afford them convenient hiding places. For further notes on aquaria, consult Leaflet No. 11.

111.—*A convenient form of aquarium jar supplied with water plants. The bottom is covered with clean sand and flat stones.*



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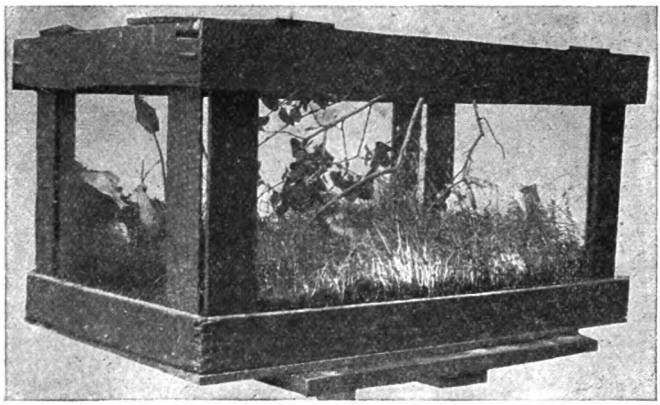
THE STORY OF A TERRARIUM FROM FALL UNTIL SPRING.

ALICE I. KENT.

And Nature, the old nurse, took
  The child upon her knee,
Saying : "Here is a story book
  Thy Father has written for thee."
—*Longfellow to Agassiz.*

Fortunate are the children and the teachers who are so placed that Nature's story book is close at hand. But city children and their teachers need not despair, for the old nurse is loving and bountiful and will rewrite, in living characters, many a page from the wondrous book, for those who care to read. One such a page



112.—*Life in the terrarium.*

may be a terrarium,—a confined plot of earth on which things may live and grow. (From *terra* "earth," as aquarium is from *aqua*, "water.") Within its narrow confines, the whole drama of the beautiful life of many a tiny creature may be rewritten.

Here is a fragment of the drama, as written in one terrarium.

This terrarium was made from an old berry-crate (Figs. 112, 113). When the children saw it first, last fall, this is what it

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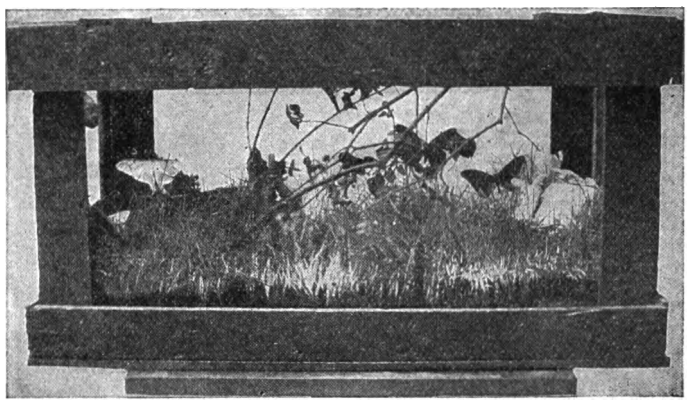
looked like: a large rectangular box, grass-green in color, thirty-nine inches long, eighteen inches wide and fifteen inches high. The long sides were of glass, the short sides and top of green wire netting. The top could be removed like the lid of a box. It stood upon a pedestal-table provided with castors. In the bottom of the terrarium were three inches of rich soil, covered with the delicate green of sprouting grass-seed. In one corner was a mossy nook, and in another a mass of thistles and clover. At one end, a small cabbage was planted, and at the other lay several sprays of glossy pin-oak. Suspended from the top, was a large spray of purple thistles.



113.—*Butterfly-time in the terrarium world.*

Amongst the thistles in the corner, ten pendants of vivid green, bright with golden points, could be seen. They were the chrysalides of the monarch, or milkweed butterfly. Amongst the cabbage leaves, were many of the pale green eggs and several of the caterpillars of the cabbage butterfly. Amongst the sprays of oak in the corner, several oak caterpillars were feeding.

Before many days had passed, the drama of life began. One by one, the chrysalides of the milkweed butterfly paled in color and, becoming transparent, showed through their whitened walls the orange colored wings of the developing butterflies within. They then burst, freeing their gorgeous tenants. This happened until there were seven butterflies in the terrarium. As two of these proved discontented with their new home, they were set

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free. The five others spent the little round of their aërial life seemingly happy and satisfied. They lived from three to six weeks and showed some individuality in their tastes and habits. Sometimes they chose the mossy corner for their resting place. On other occasions, they preferred the netting at the ends and top of the terrarium. In fact, the netting at the ends of the terrarium was a source of pleasure to these butterflies, as it served as a secure resting place and an agreeable and convenient pathway to the top. One of them spent nearly all its life on the thistles suspended from the top. These thistles were kept fresh a long time by placing their stems in a large sponge which was frequently drenched with water.

The butterflies showed some individuality in their eating also. Thistle, clover, golden-rod, nasturtiums and honey-suckle were offered to them. The thistle and the golden-rod were most frequently visited and, next to these, the nasturtiums were most favored. Another fact noted was that most of the butterflies continued to visit the flower first chosen. When, however, a thick syrup of sugar and water was offered, the flowers were much neglected, only one butterfly persisting in flower-visiting. Golden-rod was its choice. If the syrup were fresh-made every morning and placed in a convenient spot, the butterflies never failed to sip it. They generally slept clinging to the wire-netting at the ends or top of the terrarium.

In the meantime, the cabbage began to attract the watchful eyes of the wondering children. As it had industriously sent out many tiny roots, it proved a safe and satisfactory home for its hidden occupants. Shortly, one by one, the caterpillars began to appear at the edges of the uppermost leaves. Then small tours in the vicinage of the cabbage were begun and, finally, as with the butterflies, the end wire nettings proved to be an easy pathway to the top of the terrarium. Here several found good resting places and slowly changed so chrysalides.

One day a cabbage butterfly obligingly flew in at the open window. It was caught and placed in the terrarium. It, too, proved to be very fond of sugar syrup. One morning, the syrup was accidentally spilled on the wooden ridge at the bottom of the terrarium outside of the netting. The butterfly was so hungry that it could not wait for food more conveniently placed, so it

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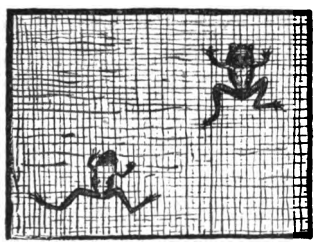
stretched its tongue out, full length, through the netting, and in that way obtained it. The children were surprised to find its tongue somewhat longer than its body.

At this time, the cabbage was removed so that the eggs and the remaining young caterpillars could be observed. The protecting coloring of the eggs and caterpillars was first noticed. One little boy at first announced that the caterpillars were green because they were not ripe, a good example surely of the danger of reasoning from analogy!

Very soon the inhabitants of this terrarium world began to increase. A father and two mother grasshoppers and a young one, with his "armor on," came to live there; also a woolly bear, several other species of caterpillars, several species of beetles, a big horse-fly, some lady-bugs and a cicada. About this time, too, some very unwelcome immigrants appeared. These were the ichneumon flies. So numerous did they become in a very short time, that they threatened desolation to this prosperous community. Nature's methods were then scrutinized and the services of two tree-toads were sought. Their response was immediate and cordial. Soon not an ichneumon fly could be found.

The grasshoppers were partial to celery, over-ripe bananas and moisture. Three days after they became inhabitants of this miniature world, the mother grasshopper dug a hole in the ground and laid eggs. The children then had before them living illustrations of the three stages of grasshopper life.

The tree-toads were both amusing and accommodating, for they, too, liked the wire-netting at the ends of the terrarium, and delighted the children by climbing up foot over foot, or hand over hand, like odd four-handed sailor boys (Fig. 114). This brought into plain view the tiny suckers on their feet.



114.—*Hand over hand.*

After the ichneumon flies had disappeared, a new difficulty arose. The ground became moldy, and the grass died down. The terrarium was then placed by an open window and left there several hours for a number of days until it was thoroughly dried out. Then

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bird-seed was planted and the ground was watered thereafter with a small plant syringe. This gave sufficient, but not excessive moisture, and it was one of the pleasures of the children to imitiate a rainy day in the terrarium world. And it was a pleasing experience, for there were splashes of water on the glass sides and many shining drops on the netting and verdure, which soon grew several inches tall; there was the same delightful odor of rich fresh earth that one enjoys during summer rains, and the sunshine touched with brilliancy the gay fall flowers and the gorgeous outspread wings of the butterflies.

At this time the terrarium had an annex in the shape of a wooden box, a foot square, with a gauze top. Here lived two mother spiders with their egg-balls carefully hung on the cobweb beams of their homes. A beautiful yellow silk egg-ball was found out of doors, one day, and when it was carefully opened to show the eggs with which it was filled, the gratifying discovery was made that these eggs were hatching. They were very tiny and very numerous.. They were inclosed in a silken pouch and were the exact color of its lining. When resting the little spiders seemed to hold their legs under the body, and they were so small and so like the egg in general appearance that if they had not run about when disturbed they would never have been discovered. As soon as the egg-ball was opened, they exploited their one talent, for they ran out on the fingers of the person who held the ball and then suspended themselves by almost invisible threads from all parts of the fingers. When they were to be returned to the egg ball, they were gently pushed up. They then obligingly ran back into their silken home, which was carefully closed as before. These little ones were kept a a week or ten days and were then allowed to escape and establish homes for themselves. The life history of the spider was thus completed, although unfortunately the adult spiders did not belong to the same species as the young ones.

To return to the terrarium: It was now early in November and each day found one or more of the terrarium inhabitants missing. One of the caterpillars disappeared and a cocoon made of its own hair was found in its place; several chrysalides were found on the top of the terrarium; the butterflies and the grass-

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hoppers, one by one, went into that sleep from which there is no awakening and a number of the other creatures disappeared. The children finally concluded that the latter had gone to sleep in the ground. The grasshoppers and the tree-toads were the last to take their rest, but just before they answered Mother Nature's call to slumber, a large garden toad came to bear them company.

He was a very interesting toad for he bore signs of having lived through what must have been almost a tragedy. He had lost the lower half of one front leg and had the scar of a long gash on his throat. These disfigurements did not cause him the least unhappiness for he had a very bright wide-awake expression and was as plump and complacent as a toad should be. The loss of his leg caused him a little inconvenience for he sometimes lost his balance when hopping and fell on his back. He occasionally found it difficult to right himself at once but a few vigorous kicks and jumps generally placed him right side up. Three days after he became a member of the terrarium community, he, too, heard Mother Nature's call to bed, and partially buried himself. Each day he covered himself more completely until finally only the top of his head and two sleepy eyes were to be seen. One day, about a week afterward, he disappeared entirely. He proved to be a very restless sleeper, and frequently showed himself during the sunniest parts of nearly every day all winter, occasionally coming entirely out of his earthy covering. He served as a sort of barometer all winter, appearing and disappearing according to bright or gloomy weather. He never, however, left the spot he had chosen for his bed.

"Winter is the night of the year," and the little terrarium world indoors exemplifies it as truly as the great fields of Nature's domain out of doors. The soil is dry and hard in this miniature world and the verdure has dried down to palest green and brown. In its earthy bed, the caterpillars, beetles, and other creatures, lie cozily asleep, and with the masses of tiny eggs, await the vivifying touch of spring.

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PLANTING A PLANT.

L. H. BAILEY.

OST persons are interested in plants, even though they do not know it. They enjoy the green verdure, the brilliant flower, the graceful form. They are interested in plants in general. I wish that every person were interested in some plant in particular. There is a pleasure in the companionship merely because the plant is a living and growing thing. It expresses power, vitality. It is a complete, self-sufficient organism. It makes its way in the world. It is alive.

The companionship with a plant, as with a bird or an insect, means more than the feeling for the plant itself. It means that the person has interest in something real and genuine. It takes him out of doors. It invites him to the field. It is suggestive. It inculcates a spirit of meditation and reflection. It enables one to discover himself.

I wish that every child in New York State had a plant of its own, and were attached to it. Why cannot the teacher suggest this idea to the pupils? It may be enough to have only one plant the first year, particularly if the pupil is young. It matters little what the plant is. The important thing is that it shall be alive. Every plant is interesting in its way. A good pigweed is much more satisfactory than a poor rosebush. The pupil should grow the plant from the beginning. He should not buy it ready grown, for then it is not his, even though he own it.

It is well to begin with some plant that grows quickly and matures early. One is ambitious in spring, but his enthusiasm may wither and die in the burning days of summer. If possible, grow the plant in the free open ground; if this is not feasible, grow it in a pot or box or tin can. Take advantage of the early spring enthusiasm. Choose hardy and vigorous plants: sow the seeds when the "spirit moves."

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If one is interested in kitchen-garden vegetables, recommend lettuce and radish, or a potato. If in flowers, suggest sweet pea, bachelor's button or blue-bottle, annual phlox, candytuft. If in fruits, suggest strawberry.

***

We desire to inaugurate a general movement this spring for the planting of plants. The school ground should be planted. Private yards should be planted. Roadsides should be planted. In some cities and villages there are committees or other organizations whose object it is to encourage planting of public and private places. Sometimes this organization is connected with the school interest, sometimes with a local horticultural or agricultural society, sometimes with a business men's organization. There should be such a committee in every village and town. We wish that the teachers might help in this work, for they would not only be lending their aid to planting, but would be interesting their pupils in some concrete and useful work, and would teach them the value of public spirit. Arbor day should be more than a mere ceremonial. It should be a means of awakening interest in definite plans for the adornment of the neighborhood and in directing the attention of the children nature-ward.

The Bureau of Nature Study will be glad to aid in any such movement in the State, so far as it may be able. We shall be glad to suggest kinds of plants, methods of organization, and the like. We have issued several papers on planting, and these are now available: Bulletin 122, "Hints on the Planting of Shrubbery;" Bull. 160, "Rural School Grounds;" Bull. 161, "Annual Flowers;" Nature-Study Leaflet No. 4, "A Children's Garden;" Leaflet No. 15, "A Handful of Soil" (Part 2).

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D. L. Bunnell

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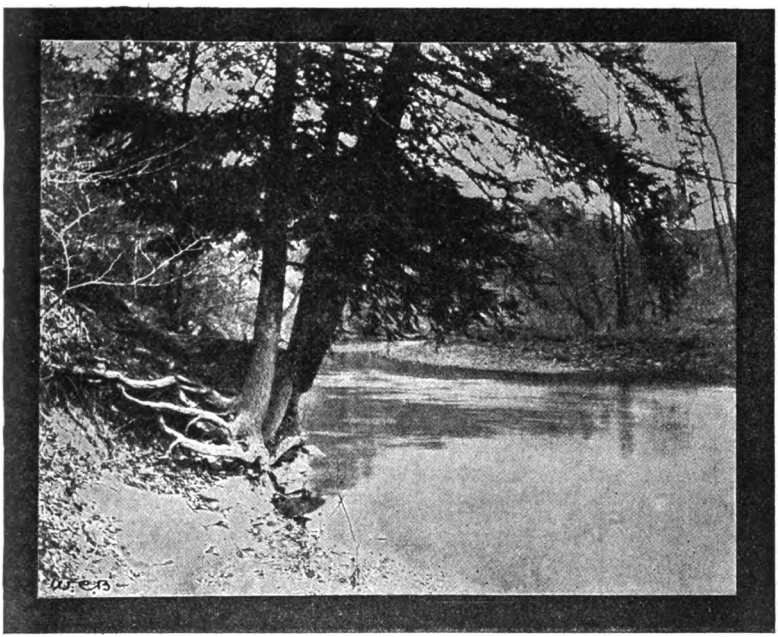
CORNELL
NATURE-STUDY QUARTERLY

No. 9.

Teacher's Leaflet No 122



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A CHAT WITH THE READER.

THIS issue is intended to complete the publication of the Nature-Study Quarterly and the Teacher's Leaflets. It is an opportune time, therefore, to have a confidential chat with the reader.

Why the publication ceases.

We cease the publication of this Quarterly because we feel that we now have sufficient Leaflets to enable us to prosecute our mission with efficiency, and because we desire to utilize our funds and energies to intensify the work that is now in progress. We began the publication of the Leaflets because we had no literature that seemed to be adapted to our needs. It has never been our purpose to continue the publication of Leaflets indefinitely. We wanted to make a sufficient number to cover a fairly wide range of subjects, and thereby to suggest useful topics and live methods for the needs of teachers in all parts of the State and under various conditions. These publications, begun in 1896, now comprise lessons on about 30 topics. These topics are sufficient in number to enable any teacher to choose lessons for a year's work, or to suggest related lines of inquiry. These Leaflets are to be kept in print. They are a part of our working capital. The more they are used, the more useful they will be. Every year the teacher has new pupils. It is easier for the teacher to instruct in the old and familiar topics than to feel that he is obliged to take up new ones each year. We hope that many new topics will be taken up, for a novel subject often renews the zeal of the teacher; but the teacher who can use these Leaflets can easily work out other subjects for himself, and we shall be glad to help him with personal suggestions. We fear that to continue to publish Leaflets would be to dissipate our efforts rather than to centralize and intensify them.

A turning point in our work.

We feel that we have now come to the close of the first epoch in our nature-study work. So far, the effort has been largely a

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propagandist movement. The work was new. By every legitimate means it must be brought to the attention of the school teachers in New York State. It must be advertized.

This preliminary work has now been largely done. Probably every teacher in the State has heard of the work, directly or indirectly. Not all teachers desire to take up nature-study work. It is not desirable that all of them, nor perhaps even half of them, should undertake it. Nature-study must take its place and chances with other school work. We have had an opportunity to discover those persons who desire to work in nature-study lines. With these persons we desire to come into closer contact, adding to our list all those who feel that they are called to teach these subjects. We want to give more direct and personal help. We want to extend and increase the work by intensifying it rather than by spreading it. We feel that our most serious and effective work has only just begun.

Is nature-study on the wane?

Real nature-study cannot pass away. We are children of nature, and we have never appreciated the fact so much as we do now. But the more closely we come into touch with nature, the less do we herald the fact abroad. We may hear less about it, but it will be because we are living nearer to it and have ceased to feel the necessity of advertizing it.

Much that is called nature-study is only diluted and sugar-coated science. This will pass. Some of it is mere sentimentalism. This also will pass. With the changes, the term nature-study may fall into disuse; but the name matters little so long as we hold to the essence.

All new things must be unduly emphasized, else they cannot gain a foothold in competition with things that are established. For a day, some new movement is announced in the daily papers, and then, because we do not see the head lines, we think that the movement is dead; but usually when things are heralded they have only just appeared. So long as the sun shines and the fields are green, we shall need to go to nature for our inspiration and our respite; and our need is the greater with every increasing complexity of our lives.

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What is nature-study?

It is a point of view. It is the acquirement of sympathy with nature, which means sympathy with what is.

As a pedagogical ideal, nature-study is teaching the youth to see and to know the thing nearest at hand, to the end that his life may be fuller and richer. Primarily, nature-study, as the writer conceives it, is not knowledge. He would avoid the leaflet that gives nothing but information. Nature-study is not method. Of necessity each teacher will develop a method; but this method is the need of the teacher, not of the subject.

Nature-study is not to be taught for the purpose of making the youth a specialist or a scientist. Now and then, a pupil will desire to pursue a science for the sake of the science, and he should be encouraged. But every pupil may be taught to be interested in plants and birds and insects and running brooks, and thereby his life will be the stronger. The crop of scientists will take care of itself.

It is said that nature-study teaching is not thorough and therefore is undesirable. Much that is good in teaching has been sacrificed for what we call "thoroughness,"—which in many cases only means a perfunctory drill in mere facts. One cannot teach a pupil to be really interested in any natural object or phenomenon until the pupil sees accurately and reasons correctly. Accuracy is a prime requisite in any good nature-study teaching, for accuracy is truth and it develops power. It is better that a pupil see twenty things accurately, and see them himself, than that he be confined to one thing so long that he hates it. Different subjects demand different methods of teaching. The method of mathematics cannot be applied to dandelions and polliwogs.

The first essential in nature-study is to see what one looks at. It is positive, direct, discriminating, accurate observation. The second essential is to understand why the thing is so, or what it means. The third essential is the desire to know more,—and this comes of itself and thereby is unlike much other effort of the schoolroom. The final result should be the development of a keen personal interest in every natural object and phenomenon.

So far as possible, nature-study should be spontaneous. To

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make it a formal part of school work, leading to perfunctory examinations, is to take the life out of it. We do not expect that the Leaflets will be used as texts. They are merely suggestions to teachers, designed to indicate the kinds of subjects that may be taken up with profit, to give subject-matter, and to point a way in which the subject may be taught.

The purpose of our work.

To improve agriculture is the purpose of our nature-study work. We believe that the most fundamental thing we can do is to give a new enthusiasm and a new point of view to the coming farmer. Nor do we hold that the coming farmer alone should be reached in order that farming be improved: we want to do something to elevate the tone of country living, and this can be done only when a general public sentiment is awakened. No longer is the farmer a man by himself: he is a man among men.

Our work is maintained by a state appropriation, given for the extending of agricultural knowledge. There are several lines of work conducted under the auspices of this state law, of which the nature-study movement is one. A coördinate movement is the Farmer's Reading-Course, in which nearly 30,000 New York farmers are now enrolled. A Reading-Course for Farmer's Wives is lately established, and about 6,000 women are enrolled in it. The literature which all these people read is prepared and furnished by the College of Agriculture. The Farmer's Reading-Course extends through three years, six Lessons being taken up each year. The eighteen Lessons comprise series on

The soil,
Animal husbandry,
Orcharding.

The Lessons are elementary statements of principles, with applications to the familiar work of the farmer. It is now proposed to introduce these Lessons as texts into such rural schools as desire to take up distinctly agricultural work, and this endeavor has been approved by Hon. Charles R. Skinner, Superintendent of Public Instruction.

While we desire to reach all the schools with the purpose of improving country life, we do not believe it to be wise to make

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the teaching of technical agriculture compulsory in any school, not even in the rural districts. To force the teaching of agriculture is to make it perfunctory and of no avail. The teacher must be trained. Public sentiment must be awakened. A desire must be created. It is a question whether any technical or professional work should be introduced into the elementary schools; but it is always advisable to awaken the pupil's interest in the things with which he lives.

How to make the rural school more efficient is one of the most difficult problems before our educators, but the problem is larger than mere courses of study. Social and economic questions are at the bottom of the difficulty, and these questions may be beyond the reach of the educator. A correspondent wrote us the other day that an old teacher, in a rural school, who was receiving $20 a month, was underbid 50 cents by one of no experience, and the younger teacher was engaged for $19.50, thus saving the district for the three months' term the sum of $1.50. This is an extreme case, but it illustrates one of the rural school problems.

One of the difficulties with the rural district school is the fact that the teachers tend to move to the villages and cities, where there is opportunity to associate with other teachers, where there are libraries, and where the wages are sometimes better. This movement is likely to leave the district school in the hands of younger teachers, and changes are very frequent. To all this there are many exceptions. Many teachers appreciate the advantages of living in the country. There they find compensations for the lack of association. They may reside at home Some of the best work in our nature-study movement has come from the rural schools. We shall make a special effort to reach the country schools. Yet, it is a fact that new movements usually take root in the city schools and gradually spread to the smaller places. This is not the fault of the country teacher, but it comes largely from the fact that his time is occupied by so many various duties, and that the rural schools do not have the advantage of the personal supervision that the city schools have.

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In conclusion.

In conclusion, let us say that we are not committed to any line of work to the exclusion of others. We hope that we have no pedagogical theories. We desire to adapt the work to conditions, so long as it promises useful results. We shall continue the publication of the Junior Naturalist Monthly. If necessary, we shall be glad to prepare leaflets on special topics in which the rural schools are interested, thus supplementing the effort to introduce the Farmer's Reading-Lessons into schools.

The summer school for nature-study, held at Cornell University, has been discontinued, at least for the time being. This school was successful and we should like to continue it; but it seemed to us that it did not prove to be the most efficient way of forwarding the agricultural work that we have in hand. The State fund is given for the extension of agricultural knowledge. By means of the summer school, we had hoped to interest and help the country teacher; but after two years' effort, we found that the teachers who came to us were largely those from the cities who were interested in nature-study primarily from the professional and pedagogical points of view. We concluded, therefore, that we could better forward the specific purposes of the State law by expending the money in other ways.

Whatever success may have been attained in this nature-study work, has been due in great part to the ready coöperation of the State Department of Public Instruction and of the teachers and parents of the State. We believe that the work has now only passed its initiate stage, and that the real and substantial progress is yet to come. We ask the aid of every person who is interested in the agricultural status. Half the people must always live in the country. We are glad that this is so. The other half draws its support and much of its vitality from the country. Every person is interested in country life.

L. H. BAILEY.

List of the Teacher's Leaflets and Related Literature.

The Teacher's Leaflets issued by the College of Agriculture of Cornell University number 22. With these Leaflets other

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nature-study literature has been published. A complete list of all these articles is given below.

In some of the earlier numbers were included articles for the Junior Naturalists, but at the present time such articles are published separately in the Junior Naturalist Monthly; these monthlies are not included in the following list. After the first 13 Leaflets, the publication took the form of a Quarterly.

LEAFLET No. 1. How a Squash Plant Gets out of the Seed. December, 1896. *L. H. Bailey.*
Also notes for the Teacher.

No. 2. How a Candle Burns. February, 1897. *George W. Cavanaugh.*
Notes for the Teacher.

No. 3. Four Apple Twigs. April, 1897. *L. H. Bailey.*
Notes for the Teacher.

No. 4. A Children's Garden. April, 1897. *L. H. Bailey.*
Notes for the Teacher.

No. 5. Some Tent Makers. June, 1897. *Anna Botsford Comstock.*
Notes for the Teacher.

No. 6. What is Nature-Study? June, 1897. *L. H. Bailey.*

No. 7. Hints on Making Collections of Insects. June, 1897. *Anna Botsford Comstock.*

No. 8. The Leaves and Acorns of our Common Oaks. October, 1897. *Alanson Phelps Wyman.*
Notes for the Teacher.

No. 9. The Life History of the Toad. May, 1897. *Simon Henry Gage*
Notes for the Teacher.

No. 10. The Birds and I. May, 1898. *L. H. Bailey.*
Notes for the Teacher.

No. 11. Life in an Aquarium. May, 1898. *Mary Farrand Rogers.*
Notes for the Teacher.

No. 12. (I) How the Trees Look in Winter. January, 1899. *L. H. Bailey.*
(II) One Way of Drawing Trees in their Winter Aspects. January, 1899. *C. W. Furlong.*

No. 13. Evergreens, and How They Shed Their Leaves. February, 1899. *H. P. Gould.*

No. 14. A Summer Shower. June, 1899. *Ralph S. Tarr.*
Junior Naturalist Leaflet No. 3. "Little Hermit Brother." (Cicada Septendecim). *Anna Botsford Comstock.*
Notes for Junior Naturalists. *Jno. W. Spencer.*
Cornell Junior Naturalist Clubs.
Miscellaneous Notes.
(a) Home Nature-Study Course.
(b) Synopsis of Extension Work.

(The above is contained in Nature-Study Bulletin No. 1, containing preface by L. H. Bailey).

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No. 15. A Handful of Soil.
I. What It Is. *R. S. Tarr.*
II. What It Does. *L. A. Clinton.*
Junior Naturalist Leaflet No. 4. Stealing a Ride. October, 1899.
I. Sir Bur, Tramp and Traveler. *Margaret Fursman Boynton.*
II. The Red Cow and the Maple Tree. *John W. Spencer.*
Notes for Junior Naturalists. A Bulb Garden.
I. A Talk by Uncle John. *John W. Spencer.*
II. A Talk by the Gardener. *C. E. Hunn.*
Club Notes.
Home Nature-Study Course. *Mary Rogers Miller.*
(Nature-Study Quarterly No. 2).

No. 16. Cuttings and Cuttings. January, 1900. *L. H. Bailey.*
Notes.
Uncle John's Talk with the Children.
(Nature-Study Quarterly, No. 3.)

No. 17. The Burst of Spring. March, 1900.
I. The Opening of the Buds. *L. H. Bailey.*
II. The Early Birds. *Louis Agassiz Fuerles.*
III. The Opening of a Cocoon. *Mary Rogers Miller.*
Notes.
(Nature-Study Quarterly, No. 4.)

No. 18. A Brook. June, 1900. *L. H. Bailey.*
I. A Brook and Its Work. *J. O. Martin.*
II. Insect Life of a Brook. *Mary Rogers Miller.*
Notes from the Clubs.
(Nature-Study Quarterly, No. 5.)

No. 19. How Plants Live Together. October, 1900. *L. H. Bailey.*
Notes.
(Nature-Study Quarterly, No. 6.)

No. 20. A Hill of Potatoes. January, 1901. *I. P. Roberts.*
Notes for the Teacher.
(Nature-Study Quarterly, No. 7.)

No. 21. A Study of Fishes. March, 1901. *H. D. Reed.*
The Story of a Terrarium from Fall until Spring. *Alice I. Kent.*
Planting a Plant. *L. H. Bailey.*
(Nature-Study Quarterly, No. 8.)

No. 22. A Chat with the Reader. *L. H. Bailey.*
Spiders. May, 1901. *John Henry Comstock.*
List of the Teacher's Leaflets and Related Literature.
(Nature-Study Quarterly, No. 9.)

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Lessons in the Farmer's Reading-Course.

Series A. The Soil and the Plant.

No. 1, 2d ed. The Soil: What it is. November, 1900. *L. H. Bailey.*
2, " Tillage and Underdrainage: Reasons why. December, 1900. *J. W. Spencer* and *John Craig.*
3, " Fertility of Soil: What it is. January, 1901. *G. W. Cavanaugh.*
4, " How the Plant gets Its Food from the Soil. February, 1901. *B. M. Duggar.*
5, " How the Plant gets Its Food from the Air. March, 1901. *B. M. Duggar.*
6, " Problem of Impoverished Lands; With Answers to Questions on previous five lessons. December, 1900. *L. H. Bailey, H. P. Gould.*

Series B. Animal Industry.

No. 7, 2d ed. Balanced Rations for Stock. December, 1900. *A.L. Knisely.*
8, " A Farmer's View of Balanced Rations. January, 1900. *S. W. Fletcher.*
9, " Sample Rations for Milch Cows. February, 1901. *LeRoy Anderson.*
10, 1st ed. Soiling Crops and Silage. March, 1901. *John Craig.*
10, Supplement. Review with answers to previous five lessons. *John Craig.* 1901. (In preparation.)

Series C. Orcharding.

11, 1st ed. A Tree. November, 1900. *John Craig.*
12, " Orcharding: A Survey of the Preliminaries. December, 1900. *John Craig.*
13, " Management of the Orchard. January, 1901. *John Craig.*
14, " Orcharding: Care of the Tree. February, 1901. *John Craig.*
15, " Orcharding: Care of the Fruit. March, 1901. *John Craig.*
16, " Orcharding: Review with answers to questions on previous five lessons. 1901. *John Craig.* (In preparation.)

Farmer's Wives' Reading-Course.

1. Saving Steps. February, 1901. *Martha Van Renssalaer.*
2. Home Sanitation. April, 1901. *Martha Van Renssalaer.*

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SPIDERS.

BY JOHN HENRY COMSTOCK.

OF all of our little neighbors of the fields there are none that are more universally shunned and feared than spiders, and few that deserve it less. There is a wide-spread belief that spiders are dangerous, that they are liable to bite, and that their bites are very venomous. Now this may be true of certain large species that live in hot countries; but the spiders of the Northern United States are practically harmless.

It is true, spiders bite and inject venom sufficient to kill a fly into the wound made by their jaws. But they are exceedingly shy creatures, fearing man more than they are to be feared. If an observer will refrain from picking up a spider there is not the slightest danger of being bitten by one; and excepting a single uncommon species no spider is known in this part of the country whose bite would seriously affect a human being.

On the other hand, spiders do much to keep in check various insect pests, and hence must be regarded as our friends. It is, however, from a different point of view that we wish to look upon them at this time. It is as illustrations of remarkable development of instinctive powers, and of wonderful correlation of structure and habit, that we would have the reader study these creatures. The teacher of nature-study can find no more available or more fertile field from which to take subjects for interesting children in the world about us. Let us then put aside our fears and go into the fields and see if we learn something of the ways of these spinners.

The funnel-web weavers.

Often on summer mornings the grass of the roadsides and fields is seen to be carpeted with little sheets of glistening silk, the webs of the grass-spider. None were observed the day before; and we wonder at the sudden appearance of this host of weavers.

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Later in the day the webs have vanished! Have the weavers rolled them up and carried them off? We remember that there was an especially fine one near the end of the veranda steps; we examine the place carefully and find that it is still there, but not so conspicuous as it was. The warm sun has dissipated the dew which rendered visible to our dull eyes the tapestry of the fields. Now that our eyes are opened we can find the webs everywhere and are impressed with a suspicion that perhaps ordinarily we see very little of what is around us.

We examine one of the webs carefully and find that it is a closely woven sheet made of threads running in all directions; that it is attached to spears of grass, and supported by numerous guy lines, and that from one side a funnel-like tube extends downwards. If, while we are watching, an insect alights on the sheet there darts from the tunnel, where she was concealed, the owner of the web, a dark-colored spider; and the insect must be agile if it escapes.

If you attempt to catch the spider it retreats to its tunnel; and when you examine the tunnel the spider is not there. You find that the tube is open below, that there is a back door by which the spider can escape when hard pressed.

We call those spiders that make webs of this kind *The Funnel-web Weavers.* They are long-legged, brown spiders, which run on the upper surface of their webs; these are usually made on grass, but sometimes they are found in the angles of buildings, and in quite high places.

The cobweb weavers.

The webs that we most often find in the corners of rooms are of a different kind and are made by the members of a family known as *The Cobweb Weavers.* In these webs there is not such a definite sheet of silk as in those of the funnel-web weavers, but instead a shapeless maze of threads extending in all directions. Many of the cobweb weavers, however, make their webs in the fields on bushes, and weave in them a flat or curved sheet, under which the spider hangs back downward. The funnel-web weavers run right side up, the cobweb weavers hang inverted. Some of the cobweb weavers do not remain in their webs, but have a

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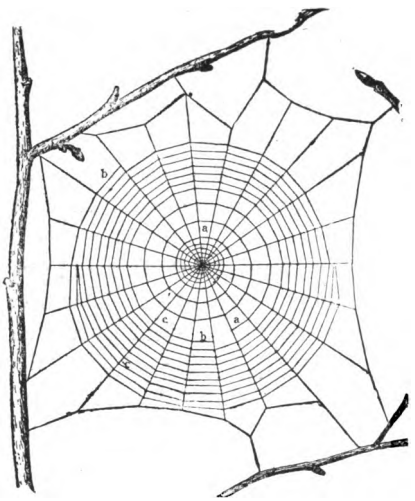
nest in a neighboring crack or corner, from which they rush to seize their prey, and sometimes there is a funnel-shaped tube leading to their nest. But these spiders differ from the true funnel-web weavers in running back downwards on the lower side of their webs.

The orb weavers.

The spider webs that most often excite admiration are those in which the supporting threads radiate from a center like the spokes of a wheel, and bear a spiral thread. Such webs are known as orb-webs; and the family of spiders that make them, *The Orb Weavers.*



115.—*Nearly completed orb-web.*

Few if any of the structures built by lower animals are more wonderful than these webs; but they are so common that they are often considered hardly worthy of notice. If they occurred only in some remote corner of the earth, every one would read of them with interest.

The webs or nets of the different species of orb weavers differ in the details of their structure; but the general plan is quite similar. There is first a framework of supporting lines. The outer part of this framework is irregular, depending upon the position of the objects to which the net is attached; but the central part is very regular, and consists of a number of lines radiating from the center of the net (Fig. 115). All of these supporting lines are dry and inelastic. Touch them with your pencil and you find that they neither stretch nor adhere to it. Upon these radiating lines there is fastened in a very regular manner a thread which is sticky and elastic. This will adhere to your pencil, and will stretch several times its normal length before breaking. Usually this sticky thread is fastened to the radiating

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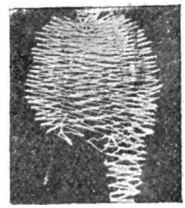
lines so as to form a spiral; but a few species make nets in which it is looped back and forth. And even in the nets where the greater part of the thread is in a spiral there are in most cases a few loops near the lower margin (Fig. 115). Examine the next orb-web you find and see if it is true in that case.

Many of the orb weavers strengthen their nets by spinning a zigzag ribbon across the center. This ribbon is made by spreading apart the spinnerets, the organs from which the silk is spun, and which will be described later. Ordinarily the tips of the spinnerets are held close together so that they form a single thread, but by spreading them apart many threads can be spun at once, thus forming a ribbon.

Some orb weavers are not content with making a simple zigzag band across the center of the net, but weave an elaborate bit of lace in this position. Figure 116 is from a photograph of the center of the net of one of these spiders, which was found near Ithaca.



116.—*Lace-like hub of an orb-web.*

In studying the various kind of orb-webs one should pay particular attention to the center of the web; for this part differs greatly in the webs of the different species. There is usually a *hub* composed entirely of dry and elastic silk woven in an irregular manner; outside of this there are several turns of a spiral thread, which is also dry; this constitutes the *notched zone*, a name suggested by the fact that the spiral line is attached for a short space to each radius it crosses, thus giving the line a notched course. In many cases it is here, on the hub and the notched zone, that the spider waits for its prey; and it is obvious that sticky silk in this place would be objectionable. Between the notched zone and the *spiral zone*, the part furnished with the sticky spiral thread; there is a clear space, the *free zone*, crossed only by the radii. This gives the spider an opportunity to pass from one side of the web to the other without going around the entire web.

Some orb weavers do not wait upon the hub but have a retreat near one edge of the net, in which they hang back downwards. While resting in these retreats they keep hold of some of the lines leading from the net, so that they can instantly detect any jar caused by an entrapped insect.

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When an insect in its flight touches one of the turns of the sticky line, the line adheres to it, but it stretches so as to allow the insect to become entangled in other turns of the line. If it were not for this elasticity of the sticky line, most insects could readily tear themselves away before the spider had time to reach them.

In running over its net, the spider steps upon the radii, carefully avoiding the sticky line; otherwise it would destroy its own net. The rapidity with which a spider can cross its net without touching the sticky line is remarkable.

In making its web an orb weaver first spins a number of lines extending irregularly in various directions about the place where its orb is to be; this is the outer supporting framework. Often the first line spun is a bridge between two quite distant points, as the branches of two separate bushes. How did the spider cross the gulf? It has no wings.

The bridge building can be easily seen on a warm summer evening, the time at which the spiders are most active repairing their old nets and building new ones. The spider lifts the hind end of its body, and spins forth a thread; this is carried off by the wind, until finally striking some object it becomes fast to it. The spider then pulls in the slack line, like a sailor, and when the line is taut fastens it to the object on which it is standing, and the bridge is formed.

After making the outward framework, the radiating lines are formed. A line is stretched across the space so as to pass through the point which is to be the center of the orb. In doing this the spider may start on one side, and be forced to walk in a very roundabout way on the outer framework to the opposite side. It carefully holds the new line up behind it as it goes along, so that it shall not become entangled with the lines on which it walks; one or both hind feet serve as hands in these spinning operations; for as the spider has eight feet, it can spare one or two for other purposes than locomotion. When the desired point is reached the slack is pulled in and the line fastened. The spider then goes to the point where the center of the orb is to be, and fastening another line, it walks back to the outer framework, and attaches this line an inch or two from the first. In

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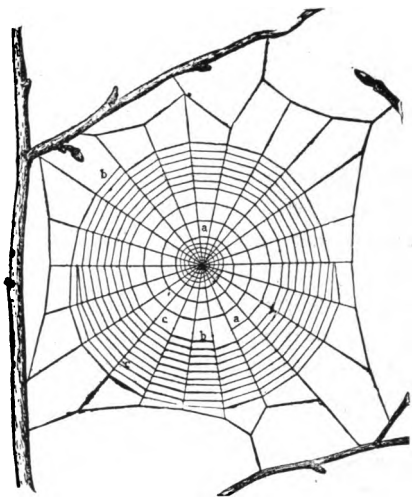
this way all of the radiating lines are drawn. The next step is to stay these radii by a spiral line, which is begun near the center, and attached to each radius as it crosses it. The turns of this spiral are as far apart as the spider can conveniently reach.

All of the threads spun up to this stage in the construction of the web are dry and inelastic. The spider now proceeds to stretch upon this framework a sticky and elastic line, which is the most important part of the web, the other lines being merely a framework to support it. In spinning the sticky line, the spider begins at the outer edge of the orb, and passing around it fastens this line to each radius as it goes. Thus a second spiral is made. The turns of this spiral are placed quite close together, and the first spiral, which is merely a temporary support, is destroyed as the second spiral progresses. Figure 117 represents a web in which the second spiral is made over the outer half of the radii. In this figure, *aa*, represents the temporary stay-line; *bb*, the sticky spiral; and *cc*, the fragments of the first spiral hanging from the radii.



117.—*Nearly completed orb-web.*

The parts of a spider.

Spiders differ much in appearance from the true insects. In the insects the body is composed of three regions: the head; the thorax, to which the legs are attached; and the abdomen or hind body (Fig. 118). In the spiders the head and thorax are grown together, forming a region which is known as the *cephalothorax;* to this the *abdomen* is joined by a short, narrow stalk (Fig. 119). Spiders differ also from insects in the number of their legs, spiders having eight legs and insects only six.

Spiders have two pairs of jaws, which, except in the Tarantula

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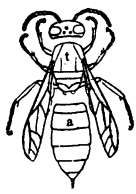
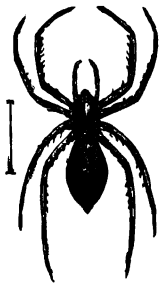
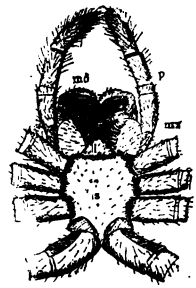
family, move sidewise like the jaws of insects. The first pair of jaws are called the *mandibles*. Each mandible consists of two segments, a strong basal one and a claw-shaped terminal one, at



118.—*Wasp, with head, thorax and abdomen separated.*



119.—*Spider, showing division of the body into cephalothorax and abdomen.*



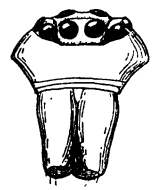
120.—*Lower side of cephalothorax of a spider;* md, *mandible;* mx, *maxilla;* p, *palpus;* l, *lower lip;* s, *sternum.*

the tip of which the poison gland opens (Fig. 120). The second pair of jaws are known as the *maxillæ*. These are situated just behind the mandibles, one on each side of the mouth. Each maxilla bears a large feeler or *palpus*. These palpi vary greatly in form; frequently, especially in females, they resemble legs; hence many spiders appear to have five pairs of legs. In the male spiders the last segment of the palpus is more or less enlarged ending in a complicated, knob-like structure (Fig. 121).

121.—*Maxilla and palpus of male house-spider.*

It is thus easy to determine the sex of a spider by merely examining the palpi.

The greater number of spiders have four pairs of eyes (Fig. 122), but there may be only one, two, or three pairs; and certain cave spiders are blind. The eyes appear like little gems set in the front of the cephalothorax.



122.—*Head of spider, showing eyes and mandibles.*

They are most prominent in the jumping spiders, which stalk their prey on plants, logs, fences, and the sides of buildings.

The most characteristic feature of spiders is their spinning organs. The silk is secreted in glands within the abdomen; and while in the body it is a fluid. It passes out through the *spinnerets*, which are situated near the hind end of the abdomen.

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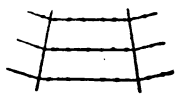
There are two or three pairs of spinnerets. These are more or less finger-like in form, and sometimes jointed (Fig. 123). Upon the end of each spinneret there are many small tubes, the *spinning tubes* (Fig. 124), from which the silk is spun. Some spiders have as many as one hundred and fifty or two hundred of these spinning tubes on each spinneret.

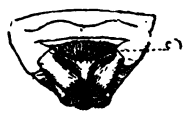
Ordinarily the tips of the spinnerets are brought close together, so that all of the minute threads that emerge from the numerous spinning tubes unite to form a single thread. Hence this tiny thread, which is so delicate that we can see it only when the light falls on it in a favorable way, is composed of hundreds of threads. It is not like a rope, composed of separate strands; for all the minute threads fuse together into a single thread.

123.—*Spinnerets of a spider.*

124.—*A group of spinning tubes.*



125.—*Viscid silk from an orb-web.*



126.—*Spinnerets and cribellum of a curled-thread weaver.*

The change in the silk from a fluid to a solid cord, strong enough to support the weight of the spider, must take place quickly after the silk comes in contact with the air on leaving the spinning tubes; the minute size of the threads coming from the spinning tubes doubtless facilitate this change.

Sometimes a spider will spread its spinnerets apart, and thus spin a broad ribbon-like band. We have seen a spider seize a large grasshopper which was entangled in its web, and rolling it over two or three times, completely envelop it in a sheet of silk spun from its spread-apart spinnerets. We have already described bands spun by orb weavers across the hub of the net in this way.

It is supposed that the two kinds of silk spun by the orb weavers are spun from different spinnerets, and that the viscid silk comes from the front pair. When this silk is first spun, the viscid matter forms a continuous layer of liquid on the outside of it. But very soon this layer breaks up into bead-like masses—in a way similar to that in which the moisture on a clothes-line on a foggy day collects into drops (Fig. 125).

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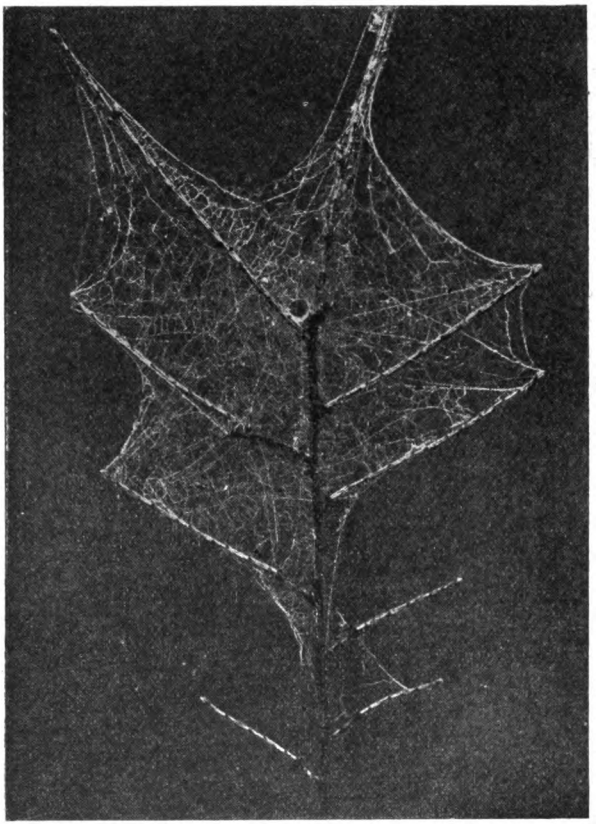
There are two families of spiders that have spinning organs differing from those of all other spiders. They have in front of the usual spinnerets an additional organ, which is named the *cribellum* (Fig. 126, c). This bears spinning tubes like the other spinneret, but these tubes are much finer. These spiders have also on the next-to-the-last segment of the hind legs one or two rows of curved spines; this organ is the *calamistrum* (Fig. 127). By means of the calamistrum these spiders comb from the

127.—*Last two segments of hind leg of spider, showing calamistrum.*



128.—*Web of a curled-thread weaver.*

cribellum a band of loose threads which form a part of their webs

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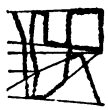
The curled-thread weavers.

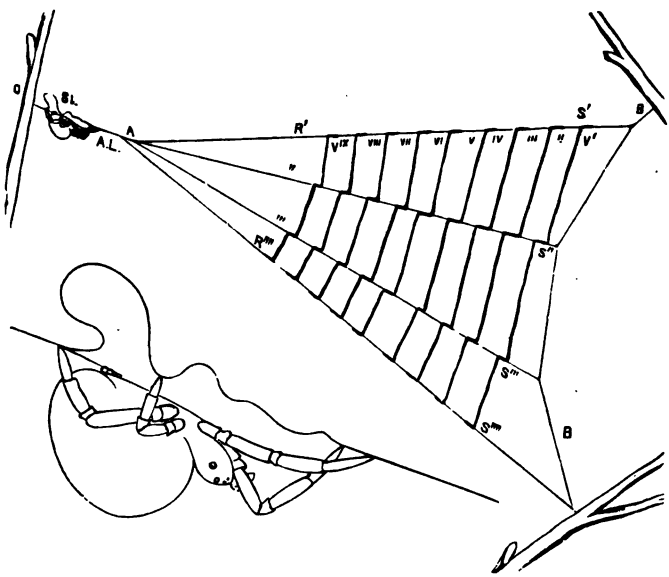
The spiders possessing a cribellum and a calamistrum represent two families, one of which makes irregular webs; the other, those which are of definite form.

An irregular web of a curled-thread weaver is shown in Fig. 128 from a photograph. In this web the framework is of ordinary silk; and upon this framework is placed a band of curled or tangled threads (Fig. 129). An insect alighting on a net of this kind is likely to get its feet caught in the tangled silk, and to be held in fast till the spider can pounce upon it. Nets of this kind are found on bushes and on the sides of buildings.



129.—*Fragment of a curled-thread weaver's web, enlarged.*

There are two quite distinct types of regular webs made by



130.—*Web of the Triangle Spider.*

spiders possessing a cribellum and a calamistrum. One is a round web which resembles at first sight those of the orb weavers; but it differs from the ordinary orb-web in that the spiral thread is made of curled or hackled silk. These webs are nearly horizon-

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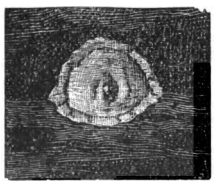
tal, and are usually made between stones or in low bushes; they are not common.

The other type is represented by the web of the Triangle Spider. This web is most often found stretched between the twigs of a dead branch of pine or hemlock. At first sight it appears like a fragment of an orb-web (Fig 130); but a little study will show that it is complete. The accompanying figure, by Dr. B. G. Wilder, who first described the habits of this spider ("Popular Science Monthly," 1875) illustrates the form of the web. It consists of four plain lines corresponding to the radiating lines of an orb-web, and a series of cross lines, which are spun by the cribellum and calamistrum. Each cross line is composed of two lines, about $\frac{1}{600}$ of an inch apart. These double lines take the place of the curled threads woven by other members of the family to which the triangle spider belongs. From the point where the radiating lines meet a strong line extends to one of the supporting twigs. Near this twig the spider rests, pulling the web tight so that there is some loose line between its legs, as shown in the enlarged figure. When an insect becomes entangled in one of the cross lines, the spider suddenly lets go the loose line so that the whole web springs forward, and the insect is entangled in other cross lines. The spider then draws the web tight and snaps it again. This may be repeated several times before the spider goes out upon the web after its prey.

The triangle spider is a tiny fellow, and so closely resembles the color of the dead branch near which it rests that it is very difficult to find; its web is more easily seen, though it usually requires careful searching to discover it.



131.—*Egg-sac of a spider.*

The motherhood of spiders.

As a rule young spiders are forced to shift for themselves, and a very hard time they have; but of this we have not space to write. With spiders, the mother's care is devoted chiefly to furnishing protection to her helpless eggs. These are placed in silken sacs, which are often very elaborate in construction and protected with great care.

The most common egg-sacs are those found in the fields

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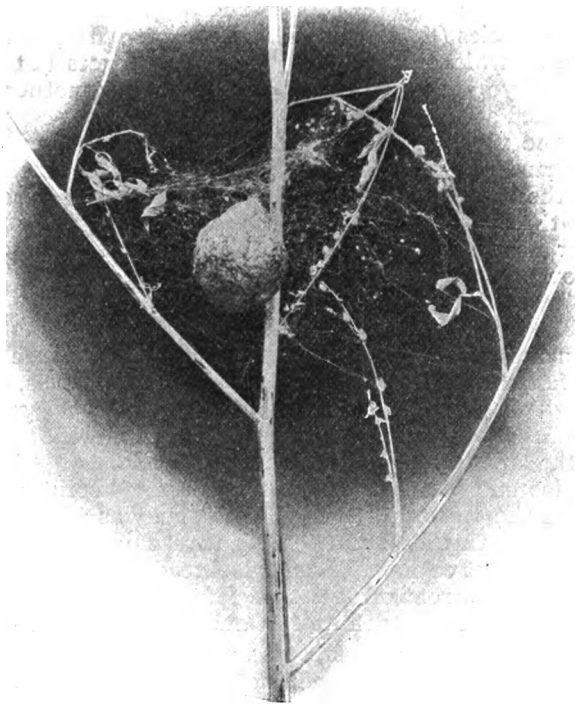
attached to stones and pieces of wood (Fig. 131). They are disk-shaped objects, silvery in color, and about the size of an old-fashioned three cent piece.

The egg-sacs of the cobweb weavers can be found suspended in their webs; and those of the orb weavers, in various situa-



132.—*Egg-sac of an orb weaver.*

tions. Figure 132 represents the large egg-sac of one of the orb weavers. This is made in the autumn, and contains at that season a large number of eggs—five hundred or more. These eggs hatch early in the winter; but no spiders emerge from the egg-sac until the following spring. If egg-sacs of this kind be opened at different times during the winter, the spiders will be found to increase in size but diminish in numbers as the season advances. In fact a strange tragedy goes on within these egg-sacs: the stronger spiders calmly devour their weaker brothers, and in the spring those that survive emerge sufficiently nourished to fight their battles in the outside world.

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The females of the *Running Spiders* not only make a carefully constructed egg-sac, but also care for the young spiders for a time. The running spiders are the large, dark-colored, hairy spiders, often found under stones and rubbish; they are so-called because they capture their prey by running. The females of most of the species (those of the genus *Lycosa*) drag after them their egg-sac, which is attached to the spinnerets (Fig. 133); and when the young hatch, they climb on their mother's back, and are carried about for a time.

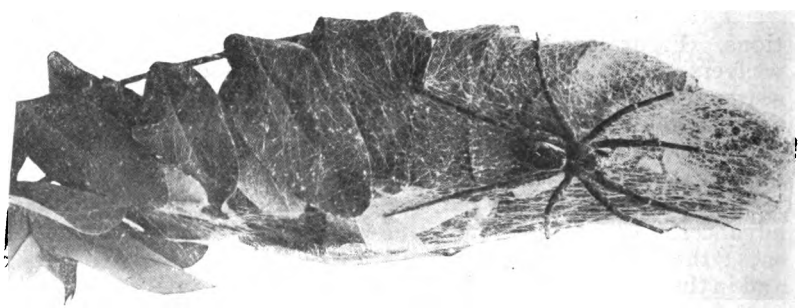
133.—*Lycosa and egg-sac.*

One of the running spiders (*Dolomedes*) carries her egg-sac with her mandibles until the young are ready to emerge. At this time the mother fastens the egg-sac in a bush, and spins irregular threads about it, among which the young spiders remain for a time (Fig. 134). In the specimen figured the egg-sac was concealed in the upper part of the web.

The ballooning spiders.

In warm autumn days, innumerable threads can be seen streaming from fences, bushes, and the tips of stalks of grass, or floating through the air. These are made by the *Ballooning Spiders*, which are able to travel long distances, hundreds of miles, through the air by means of these silken threads.

The ballooning spider climbs to some elevated point, and then, standing on the tips of its feet, lifts its body as high as it can, and spins out a thread of silk. This thread is carried up and away by a current of air. When the thread is long enough the force of the air current on it is sufficient to bear the spider up. It then lets go its hold with its feet and sails away. That these spiders travel long distances in this manner has been shown by the fact that they have been seen floating through the air at sea far from land.



134.—*Nursery of Dolomedes.*

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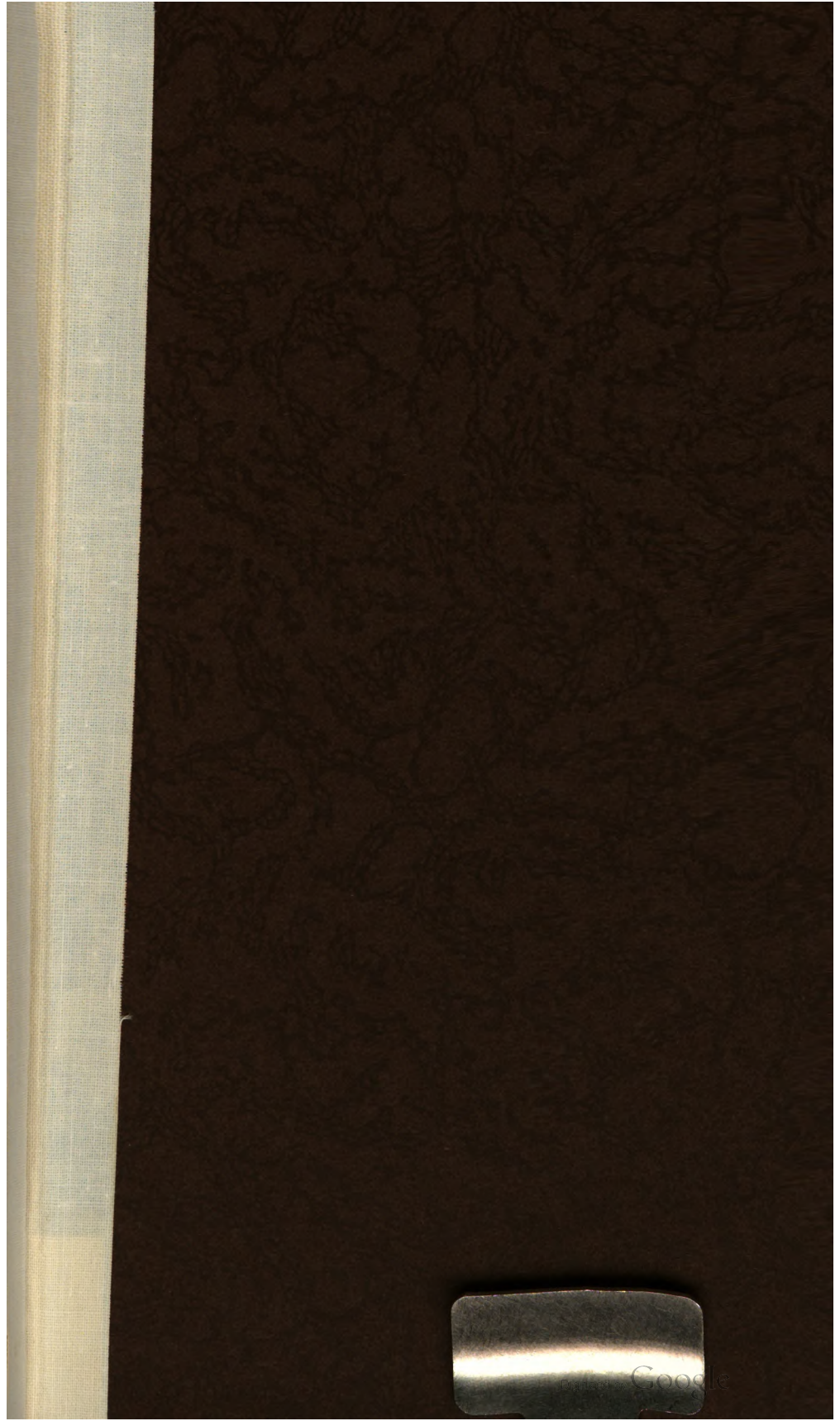
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